#115 MAY 1986 \$2.95 (3.95 CANADA

Dr. Dobb's Journal of

# Software Tools FOR THE PROFESSIONAL PROGRAMMER

# SOFTWARE DESIGN FROM THE OUTSIDE IN

Dan Bricklin's DEMO Program

Cryptographer's Toolbox

EGA Graphics & Fast PC Graphics

How to Write Memory-Resident Code







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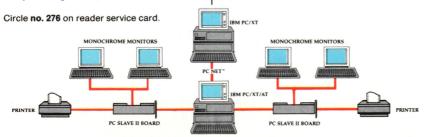
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#### Dr. Dobb's Journal of

# **Software Tools**

#### **ARTICLES**

**HUMAN INTERFACE DESIGN: From the Outside In** 

| Ever wanted to |  |
|----------------|--|
|                |  |
| redesign a     |  |
| commercial     |  |
| program's user |  |
| interface?     |  |

Why an advocate of simplicity thinks we need two cursors
Dense graphics

Tools for 
encryption and
decryption

Fast graphics

How to write a memoryresident
application

by Jim Edlin Jim Edlin here discusses designing a human interface and tools that make that job easier **HUMAN INTERFACE DESIGN: An Interview with** 32 Jef Raskin by the DDJ editors Erstwhile DDJ editor Raskin left these pages some years ago to join a startup firm, for which he conceived a computer called Mac. In a return visit, he talks about mice, modes, and his user-interface theory of operation. GRAPHICS: Simple Plots with the Enhanced Graphics 42 Adapter by Nabajyoti Barkakati The author applies an algorithm discussed in DDJ's May 1985 issue to the development of graphics primitives for fast, high-density EGA graphics. MODULA-2: A 68000 Cross Assembler—Part 2 44 by Brian R. Anderson The source code for the implementation modules. CP/M: The Cryptographer's Toolbox 58

#### COLUMNS

A set of tools useful for building encryption schemes.

C CHEST: Direct Access to the IBM Video Display
by Allen Holub

Allen presents a set of routines that break some rules to achieve blinding graphics speed.

16-BIT SOFTWARE TOOLBOX: MS-DOS Books, DOS
Tricks, PC/AT Interrupts, FORTRAN

by Ray Duncan
Ray's readers present alternate solutions to the FORTRANtc-Exec-call interface and the DOS 20-file limitation
problems.

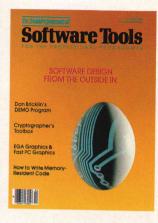
THE RIGHT TO ASSEMBLE: Code Compression with Mini-interpreters

by Nick Turner

by Fred A. Scacchitti

The new *DDJ* editor discusses techniques for crunching code for processors from the 6502 to the 68000.

#### PROGRAMMERS' **FORUM SERVICES** EDITORIAL: Who is Nick DDJ CATALOG: 113 Turner? New this month-stuff by Nick Turner from us **LETTERS:** Comments 8 **OF INTEREST: New** 122 by the programming elite products of interest **VIEWPOINT:** 12 to programmers Keep it Quiet **ADVERTISER INDEX:** 128 by Dan Appleman Where to find CARTOON: Ergonomic Art 8 that ad by Rand Renfroe **DDJ ON LINE: Threads** 14



#### **About the Cover**

Photographer Tom Upton redesigned this classic shell.

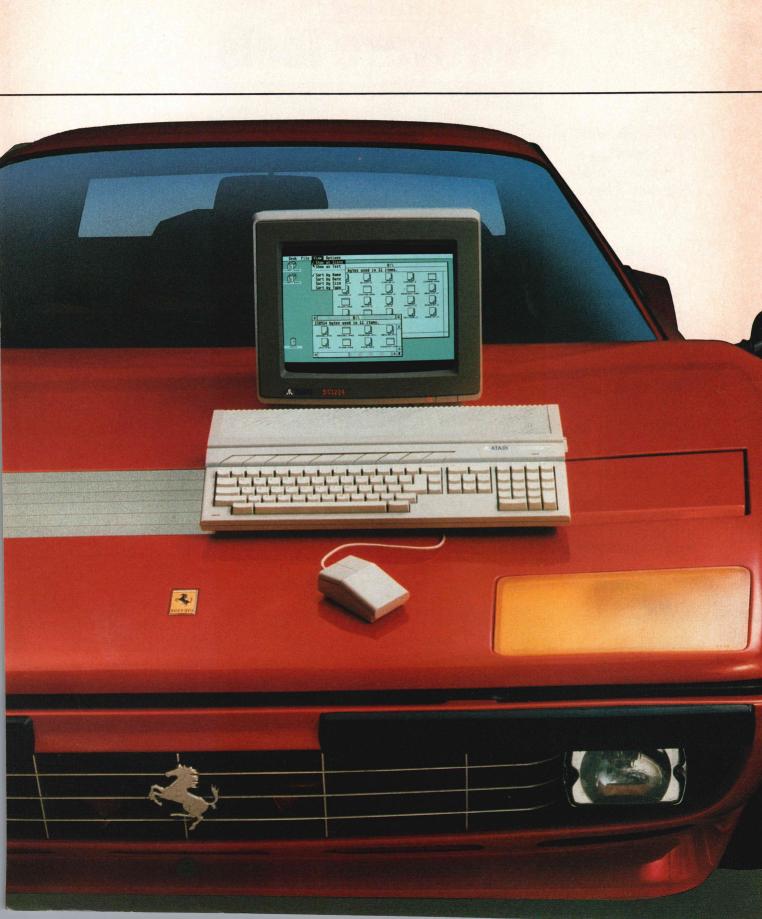
#### This Issue

With Bob Frankston, Dan Bricklin won the 1985 ACM Software System Award for inventing a new software metaphor in Visi-Calc. Bricklin's latest invention is a tool for allowing software developers to play the what-if game with their own visual metaphors before writing any code. We asked Jim Edlin to use Bricklin's program to demonstrate the process of designing from the outside in.

#### **Next Issue**

110

In June, we'll present techniques for ensuring error-free telecommunications transmission. We'll also take a closer look at Jef Raskin's unusual SwyftCard for the Apple IIe, and introduce two new columns. Structured Programming will concentrate on Algolderived languages such as Pascal, Modula-2, and Ada; and our editor-in-chief's new column will range from a look at Turbo Prolog to a satire on the issue's theme.



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The amazing new 1040ST is even more powerful than the 520ST and years ahead of all the competition at almost any price. The only question in

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| Price   | \$999                  | \$1795                   | \$4675               | \$1995               | \$1295             |
| CPU<br>Speed MHz  | 68000<br>8.0           | 68000<br>7.16            | 80286<br>6.0         | 68000<br>7.83        | 65C02<br>1.0       |
| Standard RAM  | 1 MB                   | 256K                     | 256K                 | 512K                 | 128K               |
| Standard ROM  | 192K                   | 192K                     | 64K                  | 64K                  | 16K                |
| Number of Keys  | 95                     | 89                       | 95                   | 59                   | 63                 |
| Mouse   | Yes                    | Yes                      | No                   | Yes                  | Optional           |
| Screen Resolution<br>(Non-Interlaced Mode)<br>Color<br>Monochrome | 640 x 200<br>640 x 400 | 640×200***<br>640×200*** | 640×200<br>720×350** | None<br>512 x 342    | 560×192<br>560×192 |
| Color Output  | Yes                    | Yes                      | Optional             | None                 | Yes                |
| Number of Colors  | 512                    | 4096                     | 16                   | None                 | 16                 |
| Disk Drive  | 3.5"                   | 3.5"                     | 5.25"                | 3.5"                 | 5.25"              |
| Built-in Hard Disk<br>(DMA) Port                                  | Yes                    | No                       | Yes                  | No                   | No                 |
| Midi Interface  | Yes                    | No                       | No                   | No                   | No                 |
| # of Sound Voices   | 3                      | 4                        | 1                    | 4                    | 1                  |

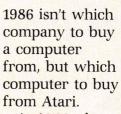
#### Atari 520ST with 512K RAM, \$799

- \*Connects to standard color T.V. For RGB color monitor add \$200.

  \*\*With optional monochrome board (non bit-mapped).

  \*\*\*Interlace Mode 640×400.

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520ST gives you 512 Kbytes of RAM, a high-resolution monochrome monitor, 2-button mouse, and 3.5" disk drive.

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And whether you choose the 520ST or the 1040ST, you'll be getting the power and speed of a Ferrari for the price of a Ford.

In fact, you'll save hundreds and in some cases thousands of dollars over comparable computers. Which is why consumers are still ecstatic. Why the critics are still writing rave reviews. And why the competition is still stunned.



## **EDITORIAL**

finally hired an editor. Now I can spend my afternoons on the beach as an editor-inchief ought to. I can also write that backof-the-magazine column I've been planning-it will appear next month. That's the new guy at the right.

I'll let him introduce himself. -Michael Swaine, editor-in-chief

I'm Nick Turner, the new editor of DDJ. I've been a professional consultant for the last few years, and before that I spent three and a half years as a game designer at Atari. (I did Super Breakout, Demons to Diamonds, and Frog Pond, and I worked with another programmer to create Snoopy and the Red Baron-all games for the 2600 VCS machine.) After I left Atari, I joined a start-up firm that promptly went under. I have worked with other companies on a consulting basis.

Now that I'm the editor, I have a chance to help guide the magazine and keep it focused. Always eclectic and pertinent, DDJ is more varied and interesting than ever. Professionals experienced in all areas of computer science submit articles that explain their freshest and most innovative ideas. I want to continue the tradition. It's an honor to be involved in a magazine with such a concerned and committed readership.

Now, down to work. We're looking for articles that feature elegant, clean, sophisticated programs. This is your chance to get involved. If you've got a program, utility, or coding technique that is really nifty, will you write it up and share it with the rest of us? Don't forget to send us a disk containing everything that you submit.

If you're in doubt about whether your manuscript would be appropriate for DDJ, why not give me a call?



You can reach me during the business day (Pacific time) at (415) 366-3600. I'll enjoy discussing our upcoming schedule with you. Here's a quick rundown of what's coming up:

Our September issue, with an author deadline of June 1,

will deal with algorithms. I'd particularly like to see something on the recent advances in linear programming. It would also be nice to have some material on real-world algorithms, for example, the algorithms used by robots to navigate complex spaces.

October focuses on the 80286 and 80386 processors. How will they compete with the 680XX and 320XX lines? What makes them more (or less) useful or efficient? How is the upgrade from the 80286 to the 80386 being handled? In particular, I'd like to see some articles with tight machine-language code. October's deadline is July 1.

November will be about graphics. This should be a really fun issue because there's been so much happening recently. I'd like to get some material on the recent advances in surface depiction, ray-tracing, particle systems, or any of the other amazing breakthroughs of the last two years. Manuscript deadline is August 1.

Finally, December will concentrate on operating systems. I'd particularly like material on the very lowest levels of operating-system design-the central kernel-where the nuts-and-bolts task handling takes place. Deadline for December is September 1.

nit In

Nick Turner

#### Dr. Dobb's Journal of

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# The C for Microcomputers

PC-DOS, MS-DOS, CP/M-86, Macintosh, Amiga, Apple II, CP/M-80, Radio Shack, PC-DOS, MS-DOM, and Cross Development systems

#### MS-DOS, PC-DOS, CP/M-86, XENIX, 8086/80x86 ROM

#### Manx Aztec C86

"A compiler that has many strengths ... quite valuable for serious work'

Computer Language review, February 1985

Great Code: Manx Aztec C86 generates fast executing compact code. The benchmark results below are from a study conducted by Manx. The Dhrystone benchmark (CACM 10/84 27:10 p1018) measures performance for a systems software instruction mix. The results are without register variables. With register variables, Manx, Microsoft, and Mark Williams run proportionately faster, Lattice and Computer Innovations show no improve-

|                     | Execution | Code   | Compile/  |
|---------------------|-----------|--------|-----------|
|                     | Time      | Size   | Link Time |
| Dhrystone Benchmark |           |        |           |
| Manx Aztec C86 3.3  | 34 secs   | 5,760  | 93 secs   |
| Microsoft C 3.0     | 34 secs   | 7,146  | 119 secs  |
| Optimized C86 2.20J | 53 secs   | 11,009 | 172 secs  |
| Mark Williams 2.0   | 56 secs   | 12,980 | 113 secs  |
| Lattice 2.14        | 89 secs   | 20,404 | 117 secs  |

Great Features: Manx Aztec C86 is bundled with a powerful array of well documented productivity tools, library routines and features.

Optimized C compiler AS86 Macro Assembler 80186/80286 Support 8087/80287 Sensing Lib Profiler Extensive UNIX Library Large Memory Model Z (vi) Source Editor -c ROM Support Package -c Library Source Code -c MAKE, DIFF, and GREP -c One year of updates -c CP/M-86 Library -c

Symbolic Debugger LN86 Overlay Linker Librarian DOS, Screen, & Graphics Lib Intel Object Option CP/M-86 Library -c INTEL HEX Utility -c Mixed memory models -c Source Debugger -c

Manx offers two commercial development systems, Aztec C86-c and Aztec C86-d. Items marked -c are special features of the Aztec C86-c system.

| Aztec C86-c Commercial System  | \$499 |
|--------------------------------|-------|
| Aztec C86-d Developer's System | \$299 |
| Aztec C86-p Personal System    | \$199 |
| Aztec C86-a Apprentice System  | \$49  |

All systems are upgradable by paying the difference in price plus \$10.

Third Party Software: There are a number of high quality support packages for Manx Aztec C86 for screen management, graphics, database management, and software development.

C-tree \$395 Greenleaf \$185 **PHACT \$250** PC-lint \$98 **HALO \$250** Amber Windows \$59 PRE-C \$395 Windows for C \$195 WindScreen \$149 FirsTime \$295 SunScreen \$99 C Util Lib \$185 Plink-86 \$395 PANEL \$295

#### MACINTOSH, AMIGA, XENIX, CP/M-68K, 68k ROM

#### Manx Aztec C68k

"Library handling is very flexible ... documentation is excellent ... the shell a pleasure to work in ... blows away the competition for pure compile speed ... an excellent effort."

Computer Language review, April 1985

Aztec C68k is the most widely used commercial C compiler for the Macintosh. Its quality, performance, and completeness place Manx Aztec C68k in a position beyond comparison. It is available in several upgradable versions.

Optimized C Creates Clickable Applications Macro Assembler Mouse Enhanced SHELL Easy Access to Mac Toolbox Overlay Linker Resource Compiler **UNIX Library Functions** Debuggers Terminal Emulator (Source) Clear Detailed Documentation Librarian Source Editor C-Stuff Library UniTools (vi, make, diff, grep) -c MacRam Disk -c Library Source -c One Year of Updates -c

Items marked -c are available only in the Manx Aztec C86-c system. Other features are in both the Aztec C86-d and Aztec C86-c systems.

| Aztec C68k-c Commercial System  | \$499 |
|---------------------------------|-------|
| Aztec C68d-d Developer's System | \$299 |
| Aztec C68k-p Personal System    | \$199 |
| C-tree database (source)        | \$399 |
| AMIGA, CP/M-68k, 68k UNIX       | call  |

#### Apple II, Commodore, 65xx, 65C02 ROM

#### Manx Aztec C65

"The AZTEC C system is one of the finest software packages I have seen"

NIBBLE review, July 1984

A vast amount of business, consumer, and educational software is implemented in Manx Aztec C65. The quality and comprehensiveness of this system is competitive with 16 bit C systems. The system includes a full optimized C compiler, 6502 assembler, linkage editor, UNIX library, screen and graphics libraries, shell, and much more. The Apple II version runs under DOS 3.3. and ProDOS, Cross versions are available.

The Aztec C65-c/128 Commodore system runs under the C128 CP/M environment and generates programs for the C64, C128, and CP/M environments. Call for prices and availability of Apprentice, Personal and Developer versions for the Commodore 64 and 128 machines.

Aztec C65-c ProDOS & DOS 3.3 \$399 Aztec C65-d Apple DOS 3.3 \$199 Aztec C65-p Apple Personal system \$99 Aztec C65-a for learning C \$49 Aztec C65-c/128 C64, C128, CP/M \$399

#### Distribution of Manx Aztec C

In the USA, Manx Software Systems is the sole and exclusive distributor of Aztec C. Any telephone or mail order sales other than through Manx are unauthorized.

#### Manx Cross Development Systems

Cross developed programs are edited, compiled, assembled, and linked on one machine (the HOST) and transferred to another machine (the TARGET) for execution. This method is useful where the target machine is slower or more limited than the HOST. Manx cross compilers are used heavily to develop software for business, consumer, scientific, industrial, research, and education-

HOSTS: VAX UNIX (\$3000), PDP-11 UNIX (\$2000), MS-DOS (\$750), CP/M (\$750), MACINTOSH (\$750), CP/M-68k (\$750), XENIX (\$750).

TARGETS: MS-DOS, CP/M-86, Macintosh, CP/M-68k, CP/M-80, TRS-80 3 & 4, Apple II, Commodore C64, 8086/80x86 ROM, 68xxx ROM, 8080/8085/Z80 ROM, 65xx ROM.

The first TARGET is included in the price of the HOST system. Additional TARGETS are \$300 to \$500 (non VAX) or \$1000 (VAX).

Call Manx for information on cross development to the 68000, 65816, Amiga, C128, CP/M-68K, VRTX, and others.

#### CP/M. Radio Shack. 8080/8085/Z80 ROM

#### Manx Aztec CII

"I've had a lot of experience with different C compilers, but the Aztec C80 Compiler and Professional Development System is the best I've seen.

80-Micro, December, 1984, John B. Harrell III

| Aztec C II-c (CP/M & ROM)  | \$349 |
|----------------------------|-------|
| Aztec C II-d (CP/M)        | \$199 |
| C-tree database (source)   | \$399 |
| Aztec C80-c (TRS-80 3 & 4) | \$299 |
| Aztec C80-d (TRS-80 3 & 4) | \$199 |

#### How To Become an Aztec C User

To become an Aztec C user call 1-800-221-0440 or call 1-800-832-9273 (800-TEC WARE). In NJ or outside the USA call 201-530-7997. Orders can also be telexed to 4995812.

Payment can be by check, COD, American Express, VISA, Master Card, or Net 30 to qualified customers.

Orders can also be mailed to Manx Software Systems, Box 55, Shrewsbury, NJ 07701.

#### How To Get More Information

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### LETTERS



#### Columns

Dear DDJ,

I have a few comments regarding Cortesi's article on disk timings in the September 1985 issue. I ran the BA-SIC timing program on TESTFILE installed on a RAMdisk. The time was 64 seconds compared to the 122 for a floppy disk. Clearly. BASIC has a considerable overhead in its internal transfer of data, apart from the disk delays. (The copy command copied the RAMdisk file in less than a second.)

Regarding the fast time of the copy command using a floppy, it seems to me that PC DOS applies mainframe techniques to its disk transfers. The fastest way to do a file copy is to transfer cylinders of data at a time. Cylinder transfers do not have to start at the lowest-numbered sector of the cylinder but can start at the first available sector and do a wraparound. The program that reads the disk in this way simply maps the sector onto the appropriate RAM address and counts sectors until all sectors of the cylinder have been read. This is the reason for the speed of a program such as copy.

I cannot let the article's implication that a freshly formatted disk has its first free data area lined up neatly on cylinder 1 pass without comment. The BASIC program and the text of the article imply that to

conduct proper timings on a physical device such as a disk, the transfers should line up on complete cylinders. The first free space on a freshly formatted disk is on track 0, sector 4, side 1. Thus the file TESTFILE is misaligned on cylinders and is spread over 17 cylinders, not 16. If, for example, a program were to loop, reading the first nine sectors of TESTFILE in order to give timings of pure reading without head movement, there would in fact be a change of cylinder, resulting in head movement. In the case of the file timings, however, the error is very slight, and the article should be noted carefully by anyone who wishes to write a fast operating system for the IBM PC.

Mike Lawrie 22 Ilchester Rd. Grahamstown 6140 South Africa Dear DDJ.

I read with interest Dan Daetwyler's comments on converting to DOS 3.0 (16-Bit Software Toolbox, December 1985). As a DOS 2.1 hacker, I have a few comments to make. In spite of his stated distaste for DOS x.0 bugs, I assume that he is using DOS 2.0 because the 20-handle limit per process is present, and enforced, already in DOS 2.1.

The limit is necessary because at address 18h in the Program Segment Prefix, DOS keeps a 20-byte array for translating the user's file handle into another number that DOS uses as an index into its array of files. I doubt that this table is longer in DOS 2.0 because the segment address of the environment is kept at address 2C. Assuming the mechanism to be the same in DOS 2.0 as in 2.1, he is causing a number of potential bugs. First of all,

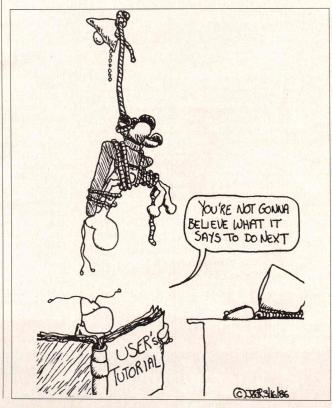
these extra file handles won't be closed automatically when the program terminates or receives a Ctrl-Break. More important, those extra file handles may have their table entries stomped on by whatever DOS does with addresses 2E-5B.

Assuming that DOS 3.1 uses this same mechanism, he might be able to get around the 20-handle limit by maintaining his own longer version of this table elsewhere. In fact, he can do everything with one file handle. For example, to open a file, he could first set [18h]=0FFh. The OPEN function call will return file handle 0, and he can move the internal DOS file index from 18h to his own table. Then when he wants to use the file, he can set [18h] to that file index and call DOS with file handle 0, and the DOS function will refer to the desired file. I should note that he will have to close all files himself upon program termination (normal or otherwise). Also, I have not tested this approach, so I give no guarantees. I merely note that COM-MAND.COM does a similar trick when bypassing I/O redirection for the "Abort, Retry, Ignore?" message.

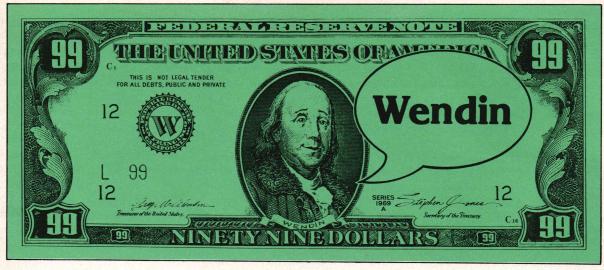
> Paul Vojta 591 Orange St. New Haven, CT 06511

Dear DDJ,

In your July 1985 issue, 16-Bit Software Toolbox began with the line "One of the most novel features added in Version 2 of MS DOS is the concept of 'installable device drivers.' "I would like to say that this concept may be new and novel for Microsoft and MS



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(continued from page 8)

DOS but it is certainly not a new and novel concept for other operating systems available for microprocessors.

The OS-9 operating system has had the concept of user-installable device drivers since its initial 6809 Level 1 release in 1978. In fact, OS-9 is totally modular in nature and allows for the user addition of new device descriptors, device drivers, and new file managers if required. On top of supporting installable drivers. OS-9 has included the "novel" MS DOS concepts of directory hierarchical structures and pipes. OS-9 also gives full support to I/O redirection, multiprocessing, and multitasking, concepts much more akin to Unix.

OS-9 may not be as well known as MS DOS is, but it does have a large following in the 6809 and 68XXX world today and is growing rapidly. MS DOS has added nothing novel to its OS; it is adding features that are expected and required for an OS in today's world. These features have been around in OS-9 and OS-9/68000 for some time.

Tim Harris Microware Systems Corp. 1866 N.W. 114th St. Des Moines, IA 50322

Dear DDJ.

This letter has a twofold purpose. The first addresses the source code LJ.C given in the September 1985 16-Bit Software Toolbox, and the second addresses C source code listings for "A New Shell for MS DOS, Part 1: IBM Cursor Control and an Fgets That Edits" in the December 1985 C Chest.

When I tried to run the LJ.C program, it would al-

ways hang up on the end of the first file to be printed. I traced the problem to the way that the end of file is found in the printpage() switch. K & R states that the variable c should be declared as type int so that the end of file (EOF) can be properly stored and tested for. Bringing the source code in line with K & R by changing the variable c to type int and changing \377 to EOF, which should be defined in stdio.h, cleared up the problem. Listing One, page 68), gives the revised source code with this correction included and modified to allow either Lattice's C compiler or Computer Innovations' C86 compiler to be used.

Also, a minor problem occurred with the source listing of LJ.C. It was hard to distinguish between the letter l (ell) and the number 1 (one) in the listing. This was especially troublesome in the escape codes to the HP LaserJet printer, where these two appear often right next to each other. It would be convenient if a typeset that differentiates between these two were used in source code listings.

There is a problem with the source listing for the new shell for MS DOS in December's C Chest that concerns the function scur(). Pagenum is passed as an argument but is not declared in scur(). This is a syntax with which I am not familiar, nor is it a syntax that I could find in either K & R or several other books on C. An explanation of this syntax in the next C Chest would be greatly appreciated.

To put the above problems in perspective, I must say that *DDJ* is the best magazine I have found for programmers. I started learning C about three

years ago solely by myself from books. It was not until a year and a half ago when I discovered *DDJ* that my real insight into programming started to surface. I attribute a lot of this to your fine magazine and the quality of the articles published. I look forward to each edition of *DDJ* more than I do to any other computer magazine.

Raymond Moon 16005 Pointer Ridge Dr. Bowie, MD 20716

Ray Duncan replies:

The program as printed in the September 1985 DDJ works properly when compiled with Lattice C, as was stated in the column. Mr. However, Moon's changes to the program to make it "standard" are correct, and will be helpful to DDJ readers who use other C compilers. An updated version of the program is available in Data Library 2 on the CompuServe DDJ Forum.

Allen Holub replies: Mr. Moon is referring to:

scur( posn, pagenum ) short posn; {

Here posn is of type short int (the int is implied), and pagenum, because it's not declared explicitly, is assumed to be of type int. That is, pagenum is declared implicitly by context. A formal argument list is one of two places in C where the type of a variable doesn't have to be spelled out. (The other is a subroutine call: If the type of the return value of a subroutine isn't declared before the subroutine is used, the compiler assumes that the subroutine returns an int.) Implicit declarations are used in

the library documentation of most compilers. I looked for a reference in K & R, and all that I could find is: "All variables must be declared before use, although certain declarations can be made implicitly by context" [Kernighan & Ritchie, The C Programming Language (Englewood Cliffs, N.J.: Prentice Hall, 1978), 36]. This is not really satisfactory. I'm sure it's spelled out in more detail somewhere in the book, but I couldn't find it. Every compiler that I know of supports implicit argument declarations though.

DDJ

(Listing begins on page 68.)



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## VIEWPOINT

#### **Keep it Quiet**

The fact that we can develop technology to make computers speak and understand human speech is not sufficient reason to let them do so. Now that progress has been made in the fields of speech synthesis and recognition, a great rush seems to be on to develop voice applications to capitalize on the technology. Many, if not most, of these applications strike me as worse than useless. There is a simple reason for this: For now and probably for decades to come, voice represents a lousy interface between man and machine.

Consider it from the first direction—computer voice synthesis. Computer speech might be a nice gimmick for a game, but it is totally inappropriate for most serious applications. The purpose of a good user interface is to make things easier for the user. Let's compare a computer voice message with the simple message tone and text on the screen that is common in many of today's applications. When the machine must gain the user's attention, a short tone is more than adequate for the task. Such a tone can register in the user's mind without demanding instant attention, thus allowing the user perhaps to complete a train of thought. Series of tones can indicate degrees

#### by Daniel Appleman

© 1986 by Daniel Appleman. Appleman is a hardware and software designer at Microlabs, in Sunnyvale, Calif. of urgency. The important thing is that such a tone leaves the user in control. The user can decide when and how to respond and how much attention to give to the machine.

With a computer voice message, the situation is radically different. The voice not only interrupts whatever the user is doing but also demands that the user interpret the message immediately. Will it become acceptable in our society for a computer to be able to interrupt a conversation between people? I certainly hope not.

A voice message can also be misunderstood easily, especially with many of today's voice synthesizers, which are devoid of expression and difficult to comprehend. Even the good ones may require several repetitions of a message for full understanding—after all, even people often need to repeat themselves. A screen message can be studied at leisure.

Worse yet, there is a tendency to make some machines talk that were clearly meant to remain silent. Most people do not require a lecture on purchasing stamps from the stamp machine in the post office. I do not appreciate a hidden voice telling me to put on my seatbelt, regardless of the how nice sounds-a pleasant buzzer and light that can be disconnected easily are sufficient.

The situation with voice recognition is even worse. Let's assume that such recognition systems will be perfected and will achieve very high (say, more than 95 percent) word recognition rates with very large vocabularies and speaker

independence. Until that time, voice recognition systems will continue to require significant discipline on the part of the user in terms of care in pronunciation and adaptation to the machine's vocabulary. Although a 95 percent word recognition rate is probably more than adequate when people speak with each other, computers with this ability will still be limited because word recognition is not sufficient. When people communicate with each other, they use many more clues to fill in where word recognition leaves off. Expression, timing, context, eye contact, body language, and even subconscious lip reading are important parts of the communication process.

Until computers can take all of these into account, they will be limited in their capability to understand the user unless the user pays conscious attention to the communication process. This defeats the original goal of making the user interface "friendly." At least with text input, people are accustomed to such discipline. It is probably possible for people to learn to communicate verbally without using nonverbal clues-but is this really desirable? Such discipline would undoubtedly carry over to society as a whole. It is one thing to make machines more human, but should we encourage a process that could make communication between people more machinelike?

Several environmental problems are created when attempting to develop a voice communication system, too. Such systems are often intolerant of background noise, requiring the user to speak loudly into the microphone in order to overcome the noise. An office with such machines would also have significant noise generated just by people talking to their computers.

There are some applications for which even today computer voice systems can be useful. They enable computers to be used by the blind. They can allow a degree of voice control of computers over the telephone. They allow voice mail systems to be built. Future applications should include voice writers (voice-to-text typewriters) and translating systems.

For now, though, the mad rush to incorporate voice systems into common computer applications is premature. Entering information into a database is much more efficient via a keyboard, and system control can be handled very nicely using today's sophisticated user-interface systems and pointing devices.

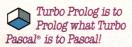
Someday my argument will no longer be valid. The HAL 9000 computer in the movie 2001-A Space Odyssey was capable of interpreting subtle nonverbal clues (including lip reading). It was also capable of learning politeness, signaling that it was about to speak with a short, electronic "throat clearing." When such computers are possible, voice communication will become both convenient and necessary-until then, let's keep them quiet.

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## DDJ ON LINE

The following is a thread of conversation from one of the message boards on the DDJ SIG:

Fm: Levi Thomas 76703.4060

I found a press release in the morning mail here at DDJ which actually contains some interesting information (rare indeed). Skipping over the fanfare and David vs. Goliath analogy, it says that Microstuf software company has filed suit against Softklone over the "look and feel" of a terminal program that Softklone distributes. The program is called Mirror and is a clone of Microstuf's Crosstalk XVI.

There was trouble of this kind concerning the proposed release of GEM but it was settled out of court, so no legal precedent was set at that time. Has this sort of thing been brought to court before? Softklone's press release goes on to say that Microstuf did not contend that its source code, object code, or user manual were copied, but claimed copyright infringement based on a single input screen. So what do you think? Should the "look and feel" of a computer program be copyrightable?

Fm: Bob Perez 76003.102 Hmm. Well, this area is certainly new, and it's hard to tell what the courts will do with it. Some observations: Close cases tend to be decided on peripheral details in order to bring the balance of evidence in alignment with the decision rendered. It's often said (and the juridicial positivists have not quarreled much with this) that judges make the law, not the legislature, and that they do so according to their perceptions of prevailing moral trends. Hence the liberalization of criminal procedures by the Warren Court during the 1960s and the other end of the spectrum currently underway by the Burger Court. If this is so, then we can expect that judges will soon be bending over backwards to try and fashion some seat-ofthe-pants remedies for what is currently being touted as "the threat of piracy." Expect to see it happen first in the copy-protection area (particularly as the issues are raised by the Shrinkwrap licensing notion) and then expect it to expand in other, deeper directions. Perhaps Apple could have presented a good test case with its threats against DRI. . . .

I can immediately see a couple of major strikes against Softklone in this case; points that can only help Microstuf in its effort to sway a judge. Naming their company Softklone was stupid. Period. But then naming their product Mirror was tantamount to mailing a "I Dare You to Sue Me" bumpersticker to Microstuf's corporate counsel. This reminds me of the obscenity litigation that Al Goldstein went though with his magazine. It was bad enough calling it Screw, but having it postmarked from Intercourse, Pennsylvania....

Fm: Chris Dunford (INF) 76703,2002

How is the Crosstalk clone conceptually different from, for example, the "store brands" that most of the big supermarket chains sell? You'll find that they sell three or four types of, say, mouthwash: One looks

identical to Scope, one to Listerine, and so on. They really go to a lot of trouble to make these things look like the original: same coloring, same bottle shape, same scent, etc. My bet is that, if Softklone has the pockets to put up a decent fight, Microstuf will fold its tent quickly. I've got a hunch it's a scare tactic, and that Les Freed and the gang know they can't win in court. Copyrighting ideas is difficult.

Fm: Bob Perez

I think there are major conceptual differences between the packaging of disposable consumer products and the appearance of a computer program's startup screen. Still, I think the point's worth noting. Maybe a better analogy could be found in the movies. Suppose I release a film that begins with loud blaring trumpets and a screen that looks very similar to the opening screen in Star Wars? Suppose the movie is called WarsClone, and suppose my company's name is LucasLike Films, Ltd. I'd suspect that Lucas's attorneys could start making their retirement plans at that point.

Fm: Chris Dunford Hmm, not sure that's a good analogy, either <scratching head>. Seems to me that there's a difference between the "feel" of a movie and the "feel" of a program. A film has nothing other than feel; it's an entirely visceral product. If I "clone" the feel of a movie, I have in effect stolen the entire product. On the other hand, a program has more than visceral effects: it does something. And I have just argued myself into a corner, haven't I? The clone-maker has cloned both the feel and the tangible effects of the program. Hmm. I still think that mouthwash provides a good analogy. Not sure I see how cloning mouthwash is conceptually different from cloning Crosstalk.

Fm: Todd M. Roy 70455,140 ... I think what has happened is that DRI folded too fast to Apple and that a lot of the big name software companies are coming out of the woodwork now to have a try at their imitators.

Fm: Dick Blowers 71555,361

I think of a computer program as a tool because that's the way I use it. I find it hard to think of "using" a novel or a movie.

Fm: Todd M. Roy 70455,140 This sort of stuff doesn't really bother me. It would bother me if one company took another company to court over the basic concept of a program, rather than a clone-like look. For example: Lotus taking everybody who ever made a spreadsheet program to court.

Fm: Robert Grimble 75206,2005

The problem is that you are not copyrighting an idea. You are copyrighting a given display. The problem with the Proctor and Gamble illustration is that bottle shapes are covered by design patents, and there are a lot more on file than there are copyrights on screen displays. Therefore, there is a lot wider coverage by the copyrighted screens, as a practical matter. You are right that the deep pocket theory has a

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(continued from page 14)

lot to do with how cases come out, but, when it comes to a user interface, there is no reason why a software developer should not be protected. It costs a lot of bucks and takes more than a little talent for a company to come up with a friendly and useful user interface. That kind of R&D is exactly what patents and copyrights are supposed to protect.

#### Fm: Bob Perez

Well, these are very tough, interesting issues. On the one hand, I agree that innovation and creativity are stifled when clones are let loose upon the world. On the other hand, Apple's position on their proprietary interface seems to assure that the marketplace will develop in many different, necessarily incompatible directions, at the expense of the very users with whom Apple seeks solidarity. Of course, it's within Apple's rights to milk it while it can. I don't think it's necessarily in their best interests to do so, however.

Fm: Jim Scheef 76505,1351 Your comment on Apple forcing the marketplace to develop many different user interfaces is an important point. Sometime in the future (probably counted in weeks in this industry) someone will realize that people are having a hard time learning to use microcomputers. The reason they will surmise is that the industry has failed to provide a standard interface that people can learn and then use for any computer. This same person, because he or she is also a member of Congress, will then propose legislation to correct this obvious oversight: You

have already seen the results of this type of legislation in many other areas. Can you imagine the results designed if Congress icons????!!! Standardization may not be all that far off as many industry watchers believe IBM will move the TopView interface to VM/ CMS and then on to all other operating systems as well. Since TopView doesn't use icons, it may not be totally germain to the thread, but Apple and others should realize that no one of them is going to get all of the graphics interface business, so why not agree on common icons that everyone can learn (the way restroom signs have become internationally standard) and use regardless of language.

Fm: Keith Moore 73267,1570

About this icon business: I seem to recall that when Apple came out with the Mac they were talking about all of the symbols stamped into their cabinet, such as the telephone receiver to indicate the modem port. Wherever an international standard for such a symbol existed, they used it. Where there was no standard symbol, they hoped that theirs would be adopted. Why should icons on the screen be different? Also, I seem to remember seeing the trash-can icon on some old Altos software many years ago.

Fm: Jim Scheef

The interpretation of copyright law is an interesting issue. Congress enacted the original copyright law to encourage authors to publish their works; i.e., make the works public. In return, the authors got the rights to publication, performance, etc. for a limited time. With a book it is easy to determine exactly what consti-

tutes the "work"-it's the words and pictures. What is the "words and pictures" of a piece of software? Is it the source code? Remember, to obtain a copyright, the author must "make public" his work. Or is the work the program's output (results)? If it is the results, then does that mean that Lotus owns all of the worksheets I put together using 1-2-3? After all, they are the results or output of the program. Or have I, by writing the spreadsheet, modified the program to produce a different result? I think that's a violation of the license agreement! The issues aren't exactly clear and I doubt we'll resolve the issue here. Going back to the Lotus example, does a program's output stop (for the purposes of copyright) with the intial screen(s) provided by the publisher? If this is true, then how will anyone ever protect an artificial intelligence program that modifies it's output depending on the responses of the user? How would you know if someone had cloned such an AI program? Even the author might not know all of the program's possible outputs!

Fm: Robert Grimble I recall that one judge commented in a computer case that "if it looked the same it was the same." There is no reason why you can't copyright an input screen, and game manufacturers shoot film of various game screens and copyright them. I'm not a copyright expert, but I think that to win a copyright case you have to show actual plagarism, which is unlike patents, where all you have to show is the use of the same device, process

Fm: Ran Talbott

(ProgGnosis) 70506,60 As I (mis?)understand the law, there are two separate issues here: The source code is clearly the "words and pictures" part. You don't send diskettes or PROMs to the copyright office: They are considered electronic representations of the original source. The appearance of the screen is treated as a separate work: Witness the Pac-Person clones that got stomped even though they ran on different machines and couldn't possibly infringe the source copyright. If Apple had successfully sued over their screen copyright, it could conceivably become illegal for anyone to publish, say, a book or magazine article containing a screen representation of a spreadsheet. A win by Apple would say: "Yes, your names (data) are different, but overall it looks like what I sent to the copyright office. Pay up."

Fm: Todd M. Roy
Another interesting point
would be to make any
copying of a program illegal. Since a program must
be loaded in from a floppy
disk to computer memory,
this is a form of copying,
and hence if all copying
were illegal, running the
program would be illegal.
Don't laugh, this isn't even
a new point.

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## C CHEST

#### Accessing IBM Video Display Memory and a Microsoft Bug

trictly speaking, it's a real no-no to read and write directly to or from the IBM PC's display memory. You're supposed to go through the ROM BIOS routines. Unfortunately, though the BIOS is faster than DOS, sometimes it's still not fast enough. This month I'm going to look at a set of C subroutines that talk directly to the IBM PC display memory. These routines are blindingly fast-blink, and you've missed the action. They'll work on all versions of the PC that exist now (at least all versions that use a monochrome adapter or equivalent-the Hercules graphics card is an equivalent), but they may not work on future hardware. In the process of writing these routines, I came across a bug in the way that the Microsoft compiler handles far pointers. I'll talk about this as I explain the code.

The routines supported are all in video.c (Listing One, page 72). They are:

void setcur (row, col) int row, col;

which positions the cursor at the indicated row and column;

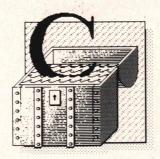
void getcur(rowp, colp)
int \*rowp, \*colp;

which gets the current cursor position (notice that *rowp* and *colp* are pointers to places where the cursor positions will be put;

void d\_putc(c, attrib)
int c, attrib;

#### by Allen Holub

which writes a single character with the indicated attribute (more on attributes in a moment) at the current cursor position and then advances the cursor. Wraparound to the next



line is supported; however, if you write past the bottom-right corner of the screen, the cursor will roll up to the top-left corner (that is, the screen doesn't scroll). Three control characters are supported: \r gets you to the beginning of the current line, \n gets you to the same column on the next line, and \b goes backward one character. All other control characters print as funny-looking IBM graphics characters of some sort (smiley faces, hearts, or whatever).

The next routine

void d\_puts(str, attrib)
char \*str;
int attrib;

writes out a string, with the characters having the indicated attribute. You must use  $\r$  to get to the left edge of the next line.

Finally,

void clrs(attrib) char \*str;

clears the screen by filling it with blanks having the indicated attribute (that is, a reverse-video attribute will fill the screen with a white background and nothing in the foreground; an underline attribute will fill the screen with underscores that is, an underlined '').

Part of the header from Listing One is reproduced in Table 1, page 20. NUMROWS and NUMCOLS define the screen size. VIDBASE is the base address of the display memory used by the monochrome adapter. The address is in cannonical form—that is, 0xb0000000 is actually address B000:0000.

Three basic attributes are supported: NORMAL video, UNDERLINED characters and REVERSE video. These are mutually exclusive (you can't have an underlined, reverse-video character). Two modifiers are supported, however: BLINKING and BOLD. The former causes the character to blink, and the latter causes it to be printed at high intensity. The modifiers may be ORed with each other and with any of the basic attributes. For example, a blinking, high-intensity underlined character has the attribute BLINKING BOLD UNDERLINED.

Characters are stored in memory as 16-bit objects. The low byte holds the ASCII code, and the high byte holds the attribute. The CHARACTER type is a structure that lets you access the ASCII code and attribute independently, without doing a shift and mask operation. If p is a pointer to a CHARACTER, then p->letter changes the ASCII field and p->attribute changes the attribute field.

DISPLAY (on line 26) is a 25 × 80 array of CHARACTERs; it's the entire display area. Screen is a pointer to a DISPLAY. The far keyword is supported by the Microsoft compiler to ease mixed-model programming. Screen is declared here as a far pointer to an array—that is, the array can be anywhere in memory and Screen is a 32-bit wide pointer to that array. If you're using the Lattice compiler, dispense with the far keyword and compile the module using the large data model.

Note that *Screen* is a pointer to the entire array, not to one element of it. Consequently individual elements of the array must be accessed with square brackets. For example, a boldface character can be written at row 5, column 10 with:

(\*Screen)[5][10].letter = 'c'; (\*Screen)[5][10].attribute =

NORMALBOLD:

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#### C CHEST

(continued from page 18)

The parentheses are required because the dot (.) has higher precedence than the \*. Without the parentheses, the expression evaluates to:

\*(Screen[5][10].letter) = 'c';

which is meaningless given the declared type of *Screen* (the compiler should kick out an error message).

Because *Screen* is never modified, it should be possible to replace it with a constant. The procedure can be explained more easily by looking at 8080 code rather than 8086 code. If you want to modify memory location 0x100 in an 8080, you can say:

#define MEM ((char \*) 0x100) x = \*MEM;

Here, you're saying treat the number 0x100 as if it were the contents of a character pointer, so \*MEM is the thing pointed to by the implied character pointer. The problem is more complicated with an 8086 because of memory segmentation, but the syntax is more or less the same. Instead of saying:

```
DISPLAY far *Screen = (DISPLAY far *) VIDBASE;
```

(\*Screen)[5][10].letter = 'c';

you should be able to say:

#define SCREEN ( (DISPLAY far \*) / VIDBASE )

(\*SCREEN)[5][10].letter = 'c';

SCREEN is treated as if it were the contents of a variable of type (DIS-PLAY far \*). You can also move the \* that precedes the use of SCREEN into the macro:

#define SCREEN ( \*( (DISPLAY far \*) VIDBASE) )

SCREEN[5][10].letter = 'c';

As it turns out, the foregoing works fine on the Microsoft compiler provided that the indexes are constants. That is:

SCREEN[5][10].letter = "";

causes the following code to be generated:

mov bx,-20480 mov es,bx mov bx,820

mov BYTE PTR es:[bx],42

```
#define NUMROWS
                              25
5
    #define NUMCOLS
                              80
                                          /* Base address of video screen
                              0xb0000000
6
    #define VIDBASE
                                            * in canonical form.
7
8
9
                                       /* Basic attributes. Only one
10
    #define NORMAL
                              0x07
                                       /* of these may be present.
                                                                             */
    #define UNDERLINED
                              0x01
11
12
    #define REVERSE
                              0x70
13
                                       /* May be ORed with the above
14
    #define BLINKING
                              0x80
15
    #define BOLD
                              0x08
                                       /* and with each other
16
17
18
19
    typedef struct
20
19
    typedef struct
20
21
         char
                 letter;
22
         char
                 attribute;
23
    CHARACTER;
24
25
26
    typedef CHARACTER
                              DISPLAY[ NUMROWS ][ NUMCOLS ];
27
    static DISPLAY far *Screen = (DISPLAY far *) VIDBASE:
28
```

where -20480 is 0xb000, 820 is the offset to row 5, column 10: 2\*((5\*80)+10) and 42 is the \*. Unfortunately, strange things happen when you try to replace the constants with variables:

```
int Row = 5;
int Col = 10;
```

SCREEN[ Row ][ Col ].letter = "\*";

generates the following:

\_Row,5 mov \_Col,10 mov mov ax.160 \_Row imul mov si,ax bx,\_Col mov bx.1 shl BYTE PTR mov [bx-1342177280][si],42

I don't know where that -1342177280 came from, but it's wrong. When you use the *Screen* variable rather than the *SCREEN* constant, everything works fine, though.

The final thing worth mentioning here is the <code>clrs()</code> routine (on line 114 of Listing One). Here, rather than use <code>Screen</code>, I've speeded up the code by declaring a pointer to an individual <code>CHARACTER</code> and then cleared the <code>Screen</code> array as if it were linear, rather than two-dimensional. This saves all the multiplies implicit in an operation involving square brackets.

Note that redirection obviously won't work when you use these routines for output, but redirection doesn't work when you use the BIOS routines either. Also, be careful about mixing these routines with normal BIOS calls. If the cursor is updated by the BIOS, then the variables Row and Col used in video.c won't correspond to the real cursor position any more (the BIOS won't update them for you) and strange things will start happening on your screen. In spite of these problems and the lack of portability, direct screen writes are very nice to have, especially if you're creating a full-screen editor or similar program, in which you have to update the screen fast.

#### **Beating Dead Horses**

At the risk of being tedious, I'm bring-

Table 1

ing up the subject of lvalues and pointers once more (this is the last of it, I promise). Steve Hersee (VP of marketing at Lattice and chair of the ISO working group in C) sent me the following paper. It was written by Gary Merrill and Francis Lynch, also of Lattice. Steve points out that the letter was submitted to, and adopted by, the ANSI comittee, so I guess the other side wins. I hate to give up \*((T)P)++, though. If you haven't already, you should read last month's column for background. The letter refers to sections in an early draft of the standard that I don't have a copy of. It's pretty understandable, though, even without the standard in front of you, and it makes some good points about lvalues.

#### Consequences of the Proposed Standard

The decision to allow an expression of the form (T)P to be an Ivalue "for purposes of additive operations on P" (when P is an lvalue of pointer type and T is the name of a pointer type) appears to preclude the development of any coherent semantics for the C language and to prevent its implementation on a significant class of machine architectures. It has the virtue, however, of bringing to light a number of places in the proposed standard where a lack of rigor and precision tend to leave the reader in a state of confusion. While this decision may initially appear plausible and even intuitively correct, the price one must pay for it quickly begins to seem excessively high, if not prohibitive.

Consider the following: Assume that P is an Ivalue of pointer type and T is the name of a pointer type. Then we know by the above principle (see Section 4.2.4) that, within the context ++(T)P (and also within the context (T)P++), the expression (T)P is an Ivalue.

On the other hand, we know from Section 4.2.1 that ++(T)P is equivalent to ((T)P+=1). So, if ++(T)P is syntactically (and semantically) acceptable, then so is ((T)P+=1). We also know (Section 4.14) that += re-

quires an Ivalue as its left operand, so everything appears to be OK so far, so long as we agree that in the context ((T)P + = 1) the subexpression (T)P is being used "for purposes of additive operations on P."

Now we also know (Section 4.14.2) that ((T)P + = 1) differs from ((T)P = (T)P + 1) "only in that" (T)P "is evaluated only once," and if this is the only difference, then since the former is acceptable syntax, so is the latter. That is, we have just been forced to regard

(1) (T)P = (T)P + 1;

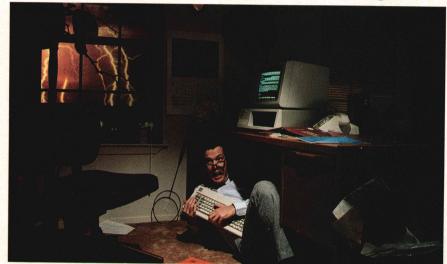
as a perfectly acceptable C expression. This requires us, of course, to agree that the first occurrence of (T)P in this expression is an lvalue.

Now come the interesting questions: if (1) is correct, then on what grounds can we possible forbid

(2) (T)P = 1 + 1;

or, in general,

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(3) 
$$(T)P = x$$
;

Our only hope is to argue that in (2) and (3) there is no "purpose" for an additive operation on *P*. So we have to be willing to say that (1) involves an additive operation on *P* while (2) does not.

But this does not really make things any clearer. How, for example, do we tell in general whether an expression is being used "for the purposes of additive operations on P?" The context of (1) is particularly simple. Shall we impose the arbitrary condition that, in order for (T)P to be considered an Ivalue in the expression

(4) 
$$(T)P = E$$

that it occur as a subexpression in *E*? What is the possible justification for this ad hoc exception to an otherwise elegant and uniform grammar? Certainly it is counterintuitive and terribly confusing to a user of the language to insist that the left occurrence of *(T)P* in *(1)* is an Ivalue but its left occurrences in *(2)* and *(3)* are not. Is what we gain worth the imposition of such an arbitrary exception to our grammar and the resulting confusion?

Note, incidentally, that the simple approach just suggested will not work, for the mere occurrence of (T)P within E does not ensure that it is used "for the purposes of additive operations on P." It may occur in E in such a way that its value is never used or is never used in assigning the new value of (T)P.

There is another reason that the simple approach of requiring (T)P to occur within E will not work. Suppose that P is a global variable and we have defined a function f such that:

```
(T) f() {
    return((T)P + 1);
```

Now consider the expression

$$(5)(T)P = f();$$

Certainly we are using (5) "for the purposes of" an additive operation on P. Can a compiler be expected to detect this purpose? Even if the definition of f() and (5) occur in different source files? To answer yes to these questions is to demand serious revision in the way we conceive of C.

#### The Semantic Problem

Now exactly what is the problem in all of these cases? It is that an attempt has been made to make a single exception to an otherwise general and formally correct rule: that a cast expression (such as (T)P) is never an lvalue. There are very good and well-known reasons for this rule, and they follow directly from the semantics for C.

The motivation for this attempt appears only to be a desire to ensure that certain dubious (at best) coding practices [Humph!-AH] will be tolerated by any compiler conforming to the proposed standard. It may be argued, for example, that if the exception is not made, then a certain amount of existing code will fail to compile under a standardized compiler. This may be true, but in light of the consequences of embracing the exception, it can hardly be looked upon as a compelling argument.

The totally misguided nature of this attempt at construing (T)P as an lvalue in a contextdependent way can be seen in the examples described above. The most immediate problem is the appeal to "purposes" in a description of the exception. Expressions of a programming language do not possess intrinsic "purposes" (though those who write them may have a purpose in doing so, of course). An appeal to "purposes" has no place in the definition of a programming language or in the document purportedly describing its standard. As it now

stands, the proposed attitude toward considering (T)P an lvalue is very close to saying that "(T)P will be considered an lvalue when the programmer wishes it to be (ie., when it is his or her purpose to use it as an lvalue), and otherwise it will not be an lvalue." Given the use of "purposes," there can be no pretense at creating a formally precise standard for the language that will enable compiler writers to implement the standard in an objective manner.

#### The Machine Problem

Another difficulty with considering (T)P an lvalue (for any purpose) is that some machine architectures require different representations for pointers to different classes of objects. Clearly, if (T)P forces a conversion of P to a different representation, there is no justification whatever for regarding the result as an Ivalue. On word-addressed machines, the example shown in 4.2.4 cannot be implemented because character pointers are simply not congruent with pointers to long integers. [A better example is the 8086 where, in the medium model, a pointer to data can be 32 bits when a pointer to a subroutine is 16 bits.—AH] Is it the intention of the proposed standard to prevent the implementation of its definition of C on such machines? The usefulness of C is such that we should make every attempt to allow its implementation on as many machines as possible; indeed, one of the principal purposes of a high-level language is to insulate programmers from the idiosyncrasies of the underlying hardware. While no attempt to embrace the entire spectrum of existing architectures is likely to be successful, surely C should not be limited to those machines that use a single pointer representation for all objects? It is true that word-addressed machines present serious problems for the large body of existing code that assumes a single pointer type. The standard, however, should be sufficiently general that it is independent of any assumptions of this kind.

#### **Possible Solutions**

What is needed?

- 1. Replace the clause "for purposes of additive operations on P" with a formally precise description of cases in which (T)P is an Ivalue. We do not believe this can be done without doing violence to a large portion of the sematics of C. The price is simply too high.
- 2. Treat (*T*)*L* (where *L* is an lvalue) as always being an lvalue. The arguments are well known and appear to be compelling.
- 3. Give up the equivalences between (++E) and (E+=1) and between (E+=1) and (E=E+1) that allowed us to generate the problematic examples above. But we cannot simply "give up" these equivalences since they are a consequence of the semantics for ++, +=, +, and =. To give them up would not only be counterintuitive but also would require a gross revision of the semantics of the operators of C. This route is impossible.
- 4. Conform to the currently accepted principle that (T)L is never an Ivalue. This now appears to be the only reasonable course, and our strong recommendation. The price we pay for it is that some previously existing code that has been accepted by some compilers will no longer be accepted by a standardized compiler. But it is hopeless and pointless for a standard to seek to preserve the acceptability of all previously existing code. The price we must pay for embracing this alternative is insignificant in comparison to what we would have to pay for any of the others.

June 8, 1984 Gary H. Merrill and Francis L. Lynch

## Putting the Shell Level into the Unix Prompt.

The MS DOS shell presented in the January-March C Chests makes the current shell level available in an environment variable. Unix doesn't. Nonetheless, in Unix it's possible to create an almost infinite number of nested shells, and it's occasionally useful to know the current level of shell nesting. The current shell level can be printed by the Unix C Shell.

This is done using the program in Listing Two, page 74, in conjunction with the shell script in Listing Three, page 74. Listing Three shows additions you should make to your .cshrc file.

DD.

(Listings begin on page 72.)

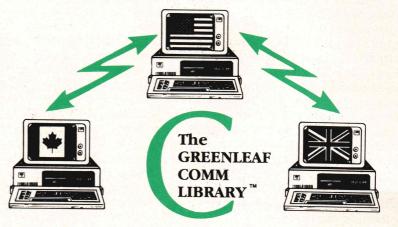
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# Human Interface Design: From the Outside In

by Jim Edlin

got into the userinterface design business by accident. Early in 1980, while searching for a word processing program for my own use, I came across one that stood well out from DEMO gives you a chance to noodle through a dozen different approaches before the programming meter starts ticking.

the herd. Naturally, I arranged to get a copy. I wanted it for drafting a sizable manuscript I had just contracted to do. What I didn't understand in making my impulsive commitment to this program was that it was still under development. I became an unwitting beta tester.

I also soon discovered that this thing that looked so beautiful and seductive on first meeting revealed some disagreeable imperfections at a closer view. The developers offered to correct some of the design flaws. Soon I became their impromptu adviser on design improvements—for example, in the case of a tab-stop setting sequence that came up with a "Column Number? \_\_\_\_\_" prompt, I told them: "When someone wants to set a tab stop, he may have no idea of what column number he wants it in. What he knows is that he wants the tab stop here," and I pointed. The tab-stop interface was changed to one where the user pointed via cursor to the desired column for the tab stop.

Since then, my involvement in user-interface design has become more formal. For one thing, I started a software company—Bruce & James Inc. My big design effort so far has been B&J's flagship product, the Wordvision word processor (actually a descendant of that program I volunteered suggestions for earlier). The design work for

Wordvision extended throughout the program's 15-month development cycle and has recently resumed in preparation for a new edition.

I have also wrestled with interface designs

for several other Bruce & James products, released and unreleased, and have evaluated interfaces for many other companies' products in the course of considering them for publication, writing about them, or informally advising their developers.

Most recently I have organized a company with the explicit mission of assisting others with user-interface design. During all my work with user interfaces, I have been seeking tools and techniques to help with the job. I've wanted to find things that would enhance my creativity and productivity, just as a word processor has aided my writing. I have tried out numerous possibilities. Until recently, I have found them all wanting.

#### **Pretenders**

My first tool was the BASIC language. I wrote BASIC programs to make prototype screen designs and to change the display in response to keystrokes. This was laborious, particularly when the screen used display features beyond simple printing of text and when it needed a lot of color and attribute painting. BASIC (particularly earlier versions) just isn't built for such jobs.

The next approach was inspired when I showed one of my BASIC prototypes to Peter Jennings, a founder of the former software giant VisiCorp. He suggested I use "storyboards." The idea seemed an obvious fit because I had worked in TV advertising, where the storyboard—a series of drawings sketching out the sequence of key im-

The Softer Interface Inc., 2355 Leavenworth, Ste. 103 San Francisco, CA 94133 ages in a commercial—is one of the fundamental tools of the trade.

Eventually, I used the storyboard approach to develop many of the preliminary designs for Wordvision. At first, however, I found storyboards unsatisfactory for the same reason that, after adapting to word processing, I now find writing on paper unpleasant. Furthermore, advertising storyboards portray generalities of visual concepts; in software I wanted to work down to the level of fine detail. Ink on paper was not malleable enough. It also didn't have a useful dimension for portraying and experimenting with flow of control—that part of the interface dealing with how the parts relate and how users move among them.

The flow-of-control question forced me to my next approach—a repeatedly reinvented series of forms on paper. These contained spaces for writing in a description of the screen display; an explanation of what events could cause the display of that screen; a list of user options while on that screen; a description of other screens or actions to which these choices would lead; and a space to describe audio, animation, and other happenings, such as use of peripheral devices.

The form kept getting revised because I continued to run up against situations that demanded entry of information for which there were no spaces on the current version of the form. Nevertheless, the forms acted as a sort of linked list and furnished fairly definitive instructions for programming. But they failed to give an overall sense of how the program would actually operate and "feel."

Eventually the forms gave way to a system of diagrams and notation formalized by a coworker. We maintained these in pencil to allow for the inevitable frequent revisions. The resulting binder became the essence of a user-interface specification. It did the recording job; but as a designer's tool, it was as cumbersome as the intricate notation used to record dance compositions. It's difficult for me to imagine a choreographer finding it more productive and rewarding to scribble pages of intricate notations than to observe action on a stage as he instructs dancers to try different moves and sequences. Likewise with interface design.

In 1984, I finally found a software tool for designing interfaces—Window Panes by Jim Canright (\$160 from Softright, P.O. Box 132, Beaverton, OR 97075; (503) 641-4072). Window Panes added a lot of leverage to my design toolbox. It consists of two subprograms: a display editor to create screen designs as either full or partial windows, and a "walker" to create and edit sequences for the windows created with the editor. The sequences can be based on keystrokes, on elapsed timings, and so forth. With Window Panes, it is possible to develop prototypes of both screen designs and flow of control in reasonable detail.

Window Panes had its drawbacks, though. First, because it was difficult to use, I never did quite master its intricacies. Second, every screen or window overlay display called for a separate disk access. Although it operated speedily with a RAMdisk, the business of getting it set up with access to the right files every time was an annoyance. I don't want to downgrade the value of Window

Panes; I considered it a true boon when it arrived, but in actual use I found it frustrating.

The version of Window Panes I used is two years old. There is a new version out that probably has improvements, and Canright tells me a still-newer version should be out by the time this article is published.

After Window Panes, the next tool I adopted was Saywhat (\$39.95 from The Research Group, 88 S. Linden Ave., South San Francisco, CA 94080; (415) 571-5019). Saywhat is a screen generator originally designed for building displays for dBASE II applications. Later The Research Group expanded it to offer the same abilities for Turbo Pascal and BASIC programs and for stand-alone screens that could be displayed from the DOS prompt with a supplied utility program.

For designing single text-mode screens, Saywhat is impressive. You can learn it easily and appreciate its ease of use. The drawback to Saywhat is in prototyping for flow of control. The only options are to create a program in one of the languages Saywhat works with or to create a DOS batch file that calls up one screen after another in sequence, with little opportunity to explore branching paths or go backward. And every screen is a file, no matter what program you use it with. Once again, operation is fast only if you use a RAMdisk, and even then it clutters your disk with files.

#### Dan Bricklin's DEMO Program

Now I have set my previous tools aside in favor of Dan Bricklin's DEMO Program, the new prototyping software by the well-known co-creator of VisiCalc. DEMO (\$74.95 from Software Garden Inc., P.O. Box 238, West Newton, MA 02165; (617) 332-2240) is the outgrowth of a tool Bricklin developed originally for his own use. It goes a long way toward the tool I have been seeking—especially at the inexpensive price, which I applaud. Had DEMO been available when we began work on Wordvision, I bet we would have shipped it at least three (financially very significant) months sooner.

I am a believer in the "artistic," as opposed to "engineering," model of program design. I think good programs evolve as their structure fills and you have a chance to see what works and what doesn't. But some programmers I know prefer to work under the engineering model. ("You don't want to redesign the bridge after it is halfway built.") In particular, it seems to me programmers don't like coding interface changes. One I often work with refers to this as "shoelace tying" programming.

DEMO gives an interface designer the chance to noodle through a dozen different approaches before the programming meter starts ticking and before any expensive data or control structures get built that would be expensive to revise. Incidentally, DEMO in no way imposes a user-interface viewpoint of its own, except for the implicit one of the choices Bricklin himself has made. To illustrate this, the sample files included with DEMO show how to implement the interface for a sample task in three significantly different ways.

#### A Hot Program

Trip Hawkins, founder of Electronic Arts, has enunciated

(continued from page 25)

a trinity of desirable qualities for a program: hot, simple, and deep. By this standard I rate DEMO in the high percentiles for both hot and deep and a bit lower but still good on simple.

Hawkins' hot criterion can be interpreted in a couple of ways. You can take it to mean raw performance—jet-propelled accomplishment of a task at hand. DEMO certainly fits that bill; for one thing, it can jump through a series of full-screen displays as fast as you can press the keys to call them up. Hot can also mean topical—filling a need. Some work is not worth doing at all until the proper tools exist to bring the job down to reasonable proportions—many of the "what if" evaluations now done with spreadsheets probably fall into this category. "What if" experimentation with user-interface approaches, and fine tuning of them, may also have fallen in this category—until DEMO.

Now let's talk deep. Frankly, I am astonished at the depth of detail and refinement Bricklin has worked into his first release of DEMO. On occasion after occasion, as the words "Wouldn't it be nice if . . ." started to take form in my mind, DEMO provided just what I was looking for. (I suppose it helps to have beta testers of the ilk of Lotus' Mitch Kapor.)

Suppose, for example, you want to print faithful images of screen designs that make generous use of line drawing and symbols from IBM's extended character set. And suppose your printer doesn't have a character set to match. DEMO gives you a mapping feature to translate screen characters to other printer characters of your choice. You can even map individual screen characters to character sequences on the printer, using a backspace to overprint two standard characters and make up a composite that approximates to one of the special IBM set (such as a caret and vertical bar to make an up arrow).

A variation of the same feature lets you translate your screen designs into a useful form for inclusion in program code. You can direct your mapped output to a text file instead of the printer and specify a C language or Pascal language mapping, which turns characters outside the normal printable set into syntactically correct octal or hexadecimal representations. (A hex format for assembly language is curiously absent.)

The fundamentally right thing about DEMO is that it combines rich sets of tools for protyping both screen designs and flow-of-control structures and integrates them into a conceptually consistent frame of reference in which it is easy to move around. There is no perceptible border to cross in going between these two areas.

#### **User Caring**

Beyond this, DEMO possesses a caring attitude toward the user that shows throughout the program in such touches as allowing you to rearrange the order of most program lists (macros, save areas, and slides). When you are drawing lines, DEMO knows what characters to put in to make a proper junction when you draw one line to join or cross another.

There is also a familiar element from VisiCalc that con-

tributes mightily to this program—one you might call "point and shoot." In the same way as you might build a spreadsheet formula by pointing to various cells, in effect saying "multiply this times (... scroll, scroll, scroll, point ...) that," you can build a screen sequence in DEMO by flipping through the screens until you see the one you want and pressing a key to say "that one."

Two other things Bricklin does right are to make it easy to get maximum mileage out of your work by reusing it as often as is applicable and to conserve your resources with this program's analog to the "sparse matrix" approach for spreadsheet data storage (where no memory is used by cell addresses that have no real contents). The power to reuse work grows out of the Overlay features, which allow you to design only one or a few basic screens, then modify them with overlays that can have areas with both "opaque" and "transparent" areas. (In the former, the underlying display is blocked out; in the latter it shows through.)

My company's programs typically use a menu-tree structure in which soft function key legends across the bottom of the screen change as the user travels through a set of menu options. For a sequence such as this, I can paint in the basic screen and then create half a dozen overlays that pop into place in the function key display area when activated by my specified keypresses.

I don't want to give the impression that there is nothing wrong with DEMO. Refinements and extensions could keep Bricklin busy for a long time. Perhaps the major limitation at the moment is that DEMO is restricted to text mode. For people working primarily or exclusively within text mode, this is not really a limitation at all. As powerful graphics displays grow more common, however, and to the extent that windowing environments play an increasing role, it will become more important for this or a similar tool to address the graphics universe. (I sure would love to see DEMO ported to the Mac and Atari ST!)

I think DEMO is weaker than it could be in the area of screen painting, particularly attributes but also ease of putting in line and symbol characters. Macros (both builtin and from a RAM-resident key macro product) can help this, but the basic weakness remains.

Although DEMO is fairly "modeless" (that is, key combinations usually do what you expect regardless of what phase of the program you are in), there is still cleanup to be done. An example is after pressing Esc-B to bring up the Block menu, you can't move the cursor before pressing B again to begin the block.

Also, the Handler capabilities (which let you specify which keystrokes or events produce which displays or actions) aren't comprehensive yet—for example, many programs use soft function key displays that change when you press the Shift (or Ctrl or Alt) key. So far, DEMO can't do handlers responding to these and other significant key actions. It also can't do much in the sound area beside beep and do simple note sequences.

#### **Low-Rent Documentation**

DEMO's documentation and packaging is self-consciously plain and low- rent. The manual is 30 pages of  $8\frac{1}{2} \times 11$ -inch, corner-stapled and instant-printed output from Bricklin's NLQ dot-matrix printer. Its contents are orga-

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nized to mirror the menus and submenus of the program's command structure.

This documentation approach is one that is often used, particularly in lower-priced programs. It is essentially an extension of the Kapor/Lotus-style on-screen interface that displays a set of command words in a menu and offers the ability to scroll through sentence-length explanations for the significance of each command word. The paper documentation in this scheme takes the same idea one level further; each command gets from one to several paragraphs of elaboration, noting all the dos, don'ts, and special cases. This approach works for getting the detail into a place where it is accessible for reference, but I have always found it lacking in the ability to explain how to use the program to achieve a user's goals. Bricklin is blunt about saying his program is designed, aimed, and packaged for those with the knowledge and motivation to make proper use of it. At least the documentation is clearly and simply written and seems not to miss much necessary detail.

Incongrously, whereas DEMO's packaging and positioning is aimed squarely at programmers, Bricklin seems to harbor ambitions of also selling it in the slideshow and training-system market. DEMO's capabilities certainly make it appropriate there, but users who want to use it for such purposes will have to overcome documentation not aimed at them. To accommodate customers in this market, Bricklin is considering some new pricing options. One possibility is an unlimited license to include RUNDEMO with a single slide show for a flat fee of \$1,000.

#### A Little Taste of DEMO

To give some flavor of what DEMO can do and how it works, I used it for a small project and noted my steps as I went. Rather than building something from scratch, I experimented with possible refinements to an existing program. For fun, I picked Zoomracks, a program designed by Paul Heckel, author of *The Elements of Friendly Software Design* (New York: Warner Books, 1984) and something of a guru on the subject of user interfaces.

Zoomracks (described in *DDJ*, November 1985) uses a card-rack metaphor. A main feature of the program is its ability, when you depress one key, to switch its view (zoom) between compressed views of several information racks and a full view of a selected rack. Within a given rack, a similar feature lets you zoom between a summary top-line view of all cards in the rack and a full view of a selected card. I like these concepts but suspected the screen visuals Heckel uses to present them might benefit from some refinement. I used DEMO to test my theory.

First I loaded the Capture utility provided on the DEMO disk. This remains resident in memory and lets you import screens from other programs into DEMO. When Capture returned me to the DOS prompt, I loaded Zoomracks, manipulated it to show the first example screen I wanted to tinker with, and pressed both Shift keys at once. Capture beeped to acknowledge it had taken a

snapshot of the screen. I then ran Zoomracks through the other three screens I wanted to work with (one view each way of both the card zoom and rack zoom), capturing each in the same way.

Exiting from Zoomracks to DOS, I then started DEMO itself. From DEMO's opening screen, I pressed Esc for the main command menu, I for the I/O menu, and R for Retrieve. Immediately, the first of my four screens—the multicard, multirack display—popped into view. In DEMO's terminology, this screen was my first *slide*.

The sequence Esc-R-H led me through the Run menu to the Handlers menu for my first slide. Handlers specify what DEMO should do from a given slide upon the occurrence of various events. Pressing the I key told DEMO to insert a new handler for that slide. A new menu displaying possible events popped on-screen; from it I chose pressing the F1 key as the event that would define a handler.

A menu of possible actions popped up. The V key told DEMO that I wanted to view another slide if F1 was pressed while the current slide was showing. DEMO, guessing I might want the next slide in the series, showed it to me with a small menu overlaid on one corner. My options were to press Return if that was the slide I wanted brought up, or to use F1, F2, or other search options to bring my choice into view. Because I wanted the third slide in my sequence—the multicard, single-rack view—I used F2 to bring it up and Return to select it.

Back on my starting slide, I pressed Esc-R-R (the Run option from the Run menu) to try out my new handler. The first slide showed, I pressed F1, and, zap—there was my zoomed-out view.

Ctrl-Break put me back in Edit mode, and I ran through the handler sequence again to say that, if F1 were pressed while viewing this slide, the earlier slide should be shown. I then went into the Run mode again to try it out. Success! Pressing F1 now bounced me back and forth between the zoomed-in and zoomed-out views, just like in the real Zoomracks program. After three minutes of work, I had a simulation duplicating a main feature of Zoomracks. It took me another couple of minutes set up the handlers to simulate the card zoom features of Zoomracks' F2 key.

Then I went back to the original slide to try my hand at visual redesign. I thought I would change Heckel's menu line at the bottom into a pull-down menu from the top instead. Moving the cursor to the menu line, I pressed Esc-B-B for the Begin choice from the Block menu. A one-character-size box appeared, and I used cursor keys to expand it around the whole menu line, then pressed Return to complete the selection and pressed S for save. I used this Named Save Area feature rather than just cutting and holding the menu in the normal cut/paste buffer because I would need to do another block operation to make space where I wanted the menu to go. A short series of keystrokes let me create a new save area, name it Menu, and put the menu line into it.

Using the Block feature again, I selected the top threequarters of the screen and used the Move option to push it down a few lines, making room for the menu at the top. Then I pasted the menu into the new space. Next, a flurry of editing and attribute painting restyled the menu

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#### **Functions** getcseg getdseg getd isascii conbuf

- conc asmx cos atan atoi bdos bdosx bios biosx
- cpystr creat curscol cursrow cursoff curson calloc delete drand ceil cfree exec chain character execl execv chdir exit chmod exitmsg clearerr exp fabs fclose
- feof ferror fflush fgets fileno filetrap find floor fopen fprintf fputs fread free freopen fscanf ftell fwrite

getc

getch

putch

isdigit putd islower getdate isprint gettime ispunct isspace isupper getkey getmode setmode itoa keypress left\$ gets len log log10 longjmp lseek malloc getw heapsiz heaptrap hypot index inp insert iofilter alloc mathtrap mid\$

mkdir

isalnum

open outp peek perror poke poscurs pow printf putc putchar puts putw read readattr reach writech readdot writedot

realloc

rename

movmem

rmdir scanf setbuf setbufsiz setcolor setdate setjmp setmem sin sound sprintf sqrt srand sscanf stacksiz

replace

repmem rewind right\$

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strcat

strenan

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#### HUMAN INTERFACE

(continued from page 28)

to my taste. For the last step on the menu, I wanted to use a graphics character for visual separation between each selection. Pressing Esc-T-C (for Typing, Characters) brought up a menu displaying special characters, and a few more keystrokes selected my choice.

I needed to use the graphics character several times for the menu and found the keystroke sequence for getting one character to be excessive. The second time, before starting, I pressed Shift-F6 to turn on the Macro Learn mode. Responding to a prompt, I assigned the sequence to the Alt-1 key, then typed the usual sequence to get my graphics character. Ctrl-Break ended the macro definition. Thereafter, I could get my graphics character just by pressing Alt-1.

The final experiment I wanted to try was to give more visual impact to the zoom process. I wanted to keep some reminder of the unzoomed racks even when a selected rack was zoomed out to occupy the whole width of the screen. Using Block functions and editing, I did some surgery on the lines at the top of the multirack screen that showed the rack structure. Then I copied these lines into the paste buffer, switched the view to the single-rack screen, and pasted the new lines in place. A little more tinkering and I had the visual effect I wanted.

I gave some thought to prototyping a little animation instead of just flipping instantly from the multirack screen to the single-rack screen. It would have been easy, starting with the two slides I had and using DEMO's overlay and handler features. But I suspected the 15 minutes of work I had already done, if actually implemented for Zoomracks, would cost hours or days of coding to accomplish; so I decided to let well enough alone.

With an Esc, an I, and an S, my work so far was saved to a disk file. Included in the file were my macro for typing the graphics character and the named save area for the menu line.

If I so desired, I could then have made up a disk for Heckel with that file and with one of my 50 alloted copies of the RUNDEMO program that comes with DEMO. Although Heckel could not modify any of my prototype work without having his own copy of DEMO, RUNDEMO would allow him to view my suggestions on his computer and to run as often as he liked through all the sequences I had defined for the F1 and F2 keys.

DDJ

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# Human Interface Design: Jef Raskin Interview

ef Raskin's involvement with personal computer user-interface design is hardly recent. In early issues of DDJ, he inveighed against needlessly complex systems. At Apple Computer, he wrote many of the company's product manuals. Later he was a member of the original Macintosh design team. Today he is the founder of Information Appliance of Menlo Park, California, which currently offers a product called Swyft-Card for the Apple IIe and IIc. DDJ will review SwyftCard next month.

Raskin cares tremendously about user-interface design, on computers and elsewhere. During our discussion he said, "As a person I'm easily frustrated. I'm very annoyed at the little things that most people put up with." He got up and walked out of the door, shutting it behind him, and immediately opened it and reentered the room. "What a nuisance! If I had two bags of groceries and a locked door! The door is a very, very bad design! Someone will have to improve it. But we're so accustomed to it that we don't think about it."

If Raskin doesn't like doors in buildings, does that mean windows on computers are also unacceptable? In the following interview with DDJ, he discusses a wide range of issues concerning user-interface design.

**DDJ:** For how long have you been thinking along human-interface design lines?

Raskin: When I was a computer center director at UC San Diego, there was a major computer center with a huge machine. I built another center. It didn't have fluorescent lights. It used minicomputers—the very early Data General Nova—and it was time sharing. Instead of submitting things

by DDJ Editors

When I go to a conference and tell people why I hate a mouse I get applause.

on punch cards in the big computer center, you could come over to this little computer center I had built, and there were 32 terminals, bean-bag chairs, and incandescent lighting with Japanese globes. You had individual terminals to work on. Students loved it. Even people from the big center would come over to use it.

We also had a language called FLOW, which had only six or seven commands and was very good for teaching programming. So working on better language design and the whole ergonomic question dates back to the 60s, when everyone else was looking at anything but that.

**DDJ:** Can you identify some of the important criteria in the design of user interfaces?

Raskin: In any user interface there's an almost unquantifiable factor of feel. And this is something I find so hard to explain. You can only achieve it by massive testing on human beings.

DDJ: Like with SwyftCard?

**Raskin:** SwyftCard is a little product for the Apple II, and we tested it on 1,500 people. There were focus group tests, one-on-one tests. There

were small-group tests. There were tests in schools. We learned a lot. We made a lot of changes and did a lot of fine-tuning.

**DDJ:** But you started with something close to the product's current user interface. You had a preconception of what would work, didn't you?

Raskin: I've been concentrating on the question of how to make systems feel good for 18 years now. Sometimes that kind of concentration produces ingrown, moribund ideas, and sometimes it produces results. I think in this case it has produced results.

DDJ: Besides feel?

Raskin: There's habit, and here we're on better theoretical ground. A system should allow a person to form habits. There are two fundamental principles that help people form habits. One of them is well known in this industry, and that is making things modeless. It's just a fact of life that people can't keep track of modes. You make mode errors when you think you're doing one thing and you press a key, but because you're in the operating system and not the editor, the system does something else. I remember in the old UCSD Pascal system, I would sometimes press E for exiting, and in some other place, it meant execute it would try to execute a letter to my mother or something. You can imagine the kinds of Pascal syntax errors you get from a letter to your mother!

**DDJ:** No modes. That sounds like an underlying rule.

Raskin: If a system is modeless, then you develop habits. If you want to do something, you just reach and do it that way—you don't get frustrated.

Modelessness has never been defined satisfactorily. It means that a given action has one and only one result. When you put the definition in that form, you can easily form a converse: To get a particular result, you want one and only one action. If that's the case then you don't have these branches. If you read Stewart Card's book The Psychology of Human Computer Interaction (Hillsdale, N.J.: Lawrence Erlbaum Associates), one of the better books in the field, you find a lot of the time you take isn't the doing time but the thinking time—working out a path. How am I going to get there from here? If you have only one way to do something, then you don't have to think about that. You can form habits even faster. If it's modeless your habits won't trip you up. In the industry we call this other property monotony, for lack of any other name. It means for a particular action, we try to have one and only one way to do it. If a system is modeless and monotonous, then you can form habits because whenever you want to do something you always do the same thing. It's like tying your shoe. Imagine if every Thursday your shoes exploded if you tied them in the usual way. This happens to us all the time with computers, and nobody thinks of complaining.

DDJ: So you have no modes, plain and simple?

Raskin: We actually did deliberately introduce one mode. We're not so doctrinaire that we won't do something when it does make sense. But our system is largely monotonous. There's generally only one way to do things. I remember reading a description of a system where the developers said, whenever they had a disagreement about how something should be done, they did it both ways. That's not a design decision.

DDJ: As in whether to use a mouse or command keys?

Raskin: Usually if you can't decide which way is better, it means you haven't found a good way to do it. On the Macintosh there's almost always a way of getting around the mouse by using the keyboard. This should have given the designers, after I left, the hint that maybe the mouse was not the right way to do it. If you're

always looking for a way around it, you've obviously got some kind of problem.

DDJ: Documentation has always been a specialty of yours. Does it enter into your definition of the user interface?

Raskin: Our user manual has something interesting in it; aside from having schematics and the usual theory of operation, here's something I've never seen in any other manual that I've ever looked at-the user-interface theory of operation, or how

we designed the user interface.

DDJ: You believe the user must understand the theory?

Raskin: No, I don't feel the user needs to know. I know, as a reader of manuals, I often wonder: Why do they do this? How did this come about? You can use the system without reading any of the theories of operation. You can learn the system by reading about 40 pages. Some people learn it from a reference card. We have only five commands. We could have had a manual that just ex-

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#### HUMAN INTERFACE

(continued from page 33)

plained the five commands. But this manual is part of our user interface.

Let's talk about manuals. We have a long, cross-referenced, handmade index. A lot of work went into this. Before we did this we typeset the manual for testing because we wanted people to feel they had a finished product. Then we got feedback not only on the product but also on the manual, so what people get as our first-edition manual is a tested manual. Manuals are an integral part of the product, not an afterthought. This whole product was designed from the very beginning with the manual in mind. In fact, the very first thing I did when I started the company was write my dream manual for this product. Then I built it and finally wrote a real manual.

**DDJ:** That brings to mind Apple's ad that boasts of the minute amount of documentation needed to learn the Mac compared to an IBM computer.

Raskin: Our first idea was to have a thin manual. We tried that—experts said, "Wonderful," but beginners said, "I don't know what I'm doing." If you say that an insert command undoes the latest block delete, people may have forgotten what a block delete is and *insert* is a funny word. We wrote the manual so we explained everything. If we had to explain something five times, we explained it five times. Don't get lazy in the manual!

**DDJ:** Beyond modelessness and monotony, what else do you have in mind as you develop a product?

Raskin: One of the most important concepts is that things you do frequently must be fast. Things that you do infrequently can be slower. People have critiqued our way of setting the widths of paragraphs, saying it seems a little baroque, but you hardly ever do it. One thing you do very often is move the cursor, and one of the big advances of this product is the cursor-moving mechanism. This was not theoretical. It hit me while

driving through Marin with my wife. No amount of theoretical analysis will give you a better system without inspiration. I know of no way of automating that process.

**DDJ:** But you began with an antipathy toward the mouse?

Raskin: I happen to hate mice, and I have since 1973 when I first started using them at Xerox PARC. I always preferred joysticks. I did want a different cursor-moving mechanism on the Macintosh. That was designed as a graphic machine, and you do need a graphic cursor-moving device. SwyftCard is nongraphic and doesn't need a graphic device. (At this point Raskin started to demonstrate the SwyftCard while he talked.)

First of all, it does not require you to move your fingers from home row, and it uses your thumbs, which are under-utilized fingers. Even in touch-typing the right thumb is used for the space bar only; the left thumb does nothing. Strangely enough, the Dvorak keyboard, for all its supposed efficiencies, doesn't use the thumbs either.

To get anywhere in about 20 pages of text, you have to type an average of 3½ characters. Research has shown that with cursor-moving keys the average time is around ten seconds, and with the mouse it drops to around four seconds. Here it drops to around a second. So it's somewhere between two and four times faster than a mouse, and it's a heck of a lot less expensive to manufacture.

**DDJ:** Had you seen anything like this that helped you in the early stages of development?

Raskin: No, after I designed this I learned about the Find command in EMAX, which is also an incremental search. It has a few problems: First of all, you have to go into Find mode; and second, it ends up on the last character of the pattern, which is a big mistake. The other thing with EMAX is, when you leap somewhere and you start typing, you're still adding into the pattern. So it's modal, and it puts you on the last character. It's only one direction.

Let me make a typical error. I want to move the cursor to the word *good*, so I should press the left Leap key and type "good." I'll press the right

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## HUMAN INTERFACE (continued from page 34)

Leap key and type. It found it anyway. The system does one thing that all systems should have done from day 1: If you tell it to search one way for something and it doesn't find it, it searches the other way in case you made a mistake. Most systems didn't do this because if you did find it then you've lost your place. In this system if you want to go back, you just bang on the keyboard. (Raskin slams both hands on the keyboard, and the cursor returns to the point in the document at which his search began.)

The other thing about this system that allows us to use this paradigm is that the longest search and display through all the text takes 300 miliseconds. Cursor motion is very important, and we've got it better than anyone. Speed is very important, and here on a stupid old 6502 running at 1 megahertz, we're moving the screen and doing things faster than you will see on any computer from any manufacturer at any price with anybody's software.

**DDJ:** On the Mac development team, was there an absence of theoretical drive?

Raskin: The original team was Bud Tribble and myself for software development. When Steve took over, Bud Tribble left. And I left. He then brought in a group of people who essentially implemented a standard operating system and just put a different appearance on the front of it. There was a strong theoretical drive initially; all the people who were doing that left. Our name for the wordprocessing program you get with the Macintosh is Macwait. If a little clock ever appears on a computer of mine, I'll shoot it. A computer is supposed to be fast.

**DDJ:** Could you talk about the cursor design on SwyftCard?

Raskin: One of the things we've done is we've paid a lot of attention to details people have taken for granted for years. The way I've gotten out of my ruts is by watching people try to learn to use our own systems. The cursor is in two parts. There is the blinking part, which we call the cursor, and the other part,

which we call the highlight. The rule is, when you type a character, it will always appear where a blinking cursor is, and whatever character was underneath it gets moved out of its way. Always. It will never happen to the right or left of the cursor. The highlight is where the next character to be deleted will be deleted when you press the Del key. When you're typing it shows exactly what's happening. I don't know how many times I've made the mistake of mispositioning a cursor on a system that deletes to the left and inserts to the right, like on the Macintosh. That causes a lot of confusion.

We spent six months before we realized a cursor has to be in two parts. We played with cursors between the letters, on the letters, cursors that flickered back and forth-dozens of designs. You always want to use a left delete after you've been typing. If you move the cursor somewhere, you always think of words from the beginning of the words. You move there, and you always want to delete the other way after you've moved the cursor. We observed that to be a 99 percent phenomenon. So we have it automatically. Whenever you leap, the cursor knows to delete to the right, and whenever you're typing, it automatically backspaces. This is definitely modal, and once in a blue moon you will make a mode error. You will press Delete and take out the wrong character. But it's so much gain.

**DDJ:** So you've eliminated many commands normally found in an application, especially in a program with several applications.

Raskin: Throwing out commands is a very big thing. This system does word processing, information retrieval, telecommunications, and calculations, and it has five commands. Any other word processor has more than five.

**DDJ:** You've complained that the Mac ended up with a traditional operating system. How does your system differ?

Raskin: We threw out the whole concept of an operating system. By definition, an operating system is the program you have to fight with before you can fight with an applica-

tion. For a single-user system on which you're not developing software, who needs an operating system? There is no operating system running underneath this. The editor runs right on the bedrock of the silicon. There are no menus. You know that people like broad, flat menus rather than deep menus. What is the broadest and flatest menu you can imagine? A few things labeled on the fronts of keys. Everything is available instantaneously and simultaneously. If I want to look up a telephone number, I don't have to get into Information Retrieval mode, I just use the Leap command. Leap is information retrieval. If I want to do a calculation, do I say "Calculation mode" or pull down the calculator? No, I simply type the equation and press the Calc button. That's the way it should always have been.

**DDJ:** The most basic concept to most interfaces is the separation between applications.

Raskin: In today's world! In tomorrow's world, interfaces like this will clobber the usual present kind, and in a few years many kinds of products will have this kind of interface.

**DDJ:** What's held people up from seeing this sort of integration?

Raskin: We already have integrated software, and that's integration by a menu. We call this homogenized. Why didn't I see this years ago? I have no idea.

**DDJ:** Can any application be homogenized?

Raskin: Yes. You name it, and I can homogenize it. The basic principle can be applied to all applications that I know of on computers. The work we've done here can be applied to any computer, small or large, and any application.

DDJ: Given the right hardware?

Raskin: Given the right software. Most people think the Apple II is the wrong hardware for any spiffy human interface. Part of the problem is this doesn't show up on television. All you see is your work. But isn't that what you want to see? Do you want to see the computer mechanism, or do you want to see your work? We don't waste any of the

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  easy feature to achieve on the 370,
  especially if you use non-constant
  external variables, but we did it.
- Optimization of the generated code. We know the 370 instruction set and the various 370 operating environments. We have over 100 staff years of assembler language systems experience on our development team.
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- Generated code identical for OS and CMS operating systems. You can move modules between MVS and CMS without even recompiling.
- Complete libraries. We have implemented all the library routines described by Kernighan and Ritchie (the informal C standard), and all the library

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#### HUMAN INTERFACE

(continued from page 36)

screen with indicators or messages. It's all yours. On a 64K Apple II with our system, the user gets 40K. If you buy a 128K Mac and MacWrite, you get 20K out of 128K. Our entire code for this product is 14.5K. Nobody even thinks you can write an application, much less four or five applications, in under 16K bytes. Those numbers have not been heard for years. Go back to the early days of DDJ!

**DDJ:** But you must feel some frustration with this product on the Apple II?

Raskin: Sure. The keyboard layout isn't optimal. The Leap keys should be larger. They weren't designed for leaping use. There are many applications on other hardware that we simply don't do here. For one thing, we don't have the spreadsheet integrated because the Apple finally ran out of power at a certain point. But the hardware is not so important. And the amount of stuff you can do with an 8-bit processor and even 16K bytes of memory have not been exhausted by humanity and will never be.

People like Steve Jobs say that the way to get simplicity is greater complexity. Well, they don't put it quite that boldly. What they say is, if we have intelligent enough systems and big enough systems, we can make them very easy to use. I have this stupid idea of simplicity via simplicity—and for many applications it works. I'm not denigrating all of AI and that stuff. I think there's a lot to be gained from it but not for little things that people are going to use on an everyday basis.

I was a visiting scholar in the artificial intelligence lab at Stanford, and I had an office at PARC. I was never an employee at PARC.

**DDJ:** So you think the mouse created a barrier toward designing better user interfaces. What's better for graphics?

Raskin: My favorite graphic input device is a tablet. That's what I find easiest to use. It feels like a pencil. I spent years practicing, using pencils. I've thought the mouse was a mistake for a decade and a half now. I think it's being foisted on a lot of people. When I go to a conference and I tell people why I hate a mouse, I usually get applause.

**DDJ:** Specific applications create certain needs in interface design. What's an example of this?

Raskin: Most people who do a lot of heavy telecommunications end up having two computers because, if you want to receive messages at an arbitrary time, you have to leave your telecom package up. With your telecom package up, you can't do anything else. On this system, it's always in Telecom mode. If you send me a message, whether I'm working or not, I won't be interrupted. If I'm not there, it'll just accept it; if I am there, I can finish my thought and then read your message. So here's a place where modelessness buys you a whole computer.

**DDJ:** Have the main issues changed in terms of what a programmer wants and a user needs?

Raskin: I think so. There are some programmers I haven't hired here because they say, "Hey I'm not going to get a chance to hack at systems or Unix or anything like that here." The programmers we do have here have as their first priority making things work well with people. That means you can't have an interest in developing a new and better operating system. In a few years all computer-science departments will user-interface courses; some do now. And that will become more and more recognized as legitimate and worthy. We have to have a stronger theory of human interfaces. Part of what I'm doing is developing such a theory in my spare time.

**DDJ:** What would you concentrate on in a user-interface class?

Raskin: First of all, you've got to get people to recognize when they're having trouble. People always say, "It's me," but it's the computer design that's so dumb. So first, you have to get programmers out of the cocky position of believing they know how to design stuff and to a humble position that if a person is having a problem, it's not the person who's dumb, it's a dumb design. That's the start. And have them learn statistics and

experimental design. And then understanding how human beings learn and work—cognitive psychology and learning theory.

**DDJ:** Will different languages help in the creation of better interfaces?

Raskin: Definitely. We used Forth. That helped us here because it was small and runs like a bat out of hell. You don't have many compunctions about dropping down to assembly language if you really need speed. So for sheer performance, it was a good choice. For human-interface design, most of the languages like PROLOG and LISP or APL are totally inappropriate. I've been reading some articles about people writing simulators on which you can test human design interfaces. They say it's very slow, which invalidates it. Unless they can simulate the real speed, they're not getting any useful data. There's no language per se.

**DDJ:** What thoughts did you have along these lines while you were doing things for *DDJ*?

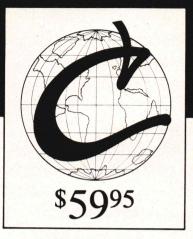
Raskin: Go back and read the very first article I ever published in 1976 in DDJ. Read Jim Warren's little comment about me at the bottom. ["Jef Raskin is well known for his heretical belief that people are more important than computers and that computer systems should be designed to alleviate human frailties, rather than have the human succumb to the needs of the machine."] It's still true, word for word. I've been trying to fulfill that belief ever since.

#### DDJ

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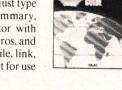


#### C Programming Guide \$ After reading the 1st edition.

Jerry Pournelle (BYTE Magazine) said: "I recommend this book ... Read it before trying to tackle Kernighan and Ritchie." The second editon expands this best seller and walks you through the C language in an easy-to-understand manner. Many of the error messages include references to this book making it a perfect companion to Eco-C88 for those just starting out with C.

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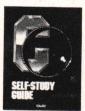


#### C Self-Study Guide

(Purdum, Que Corp.). Designed for those learning C on their own. The book is filled with questions-answers designed to illustrate many of the tips, traps, and techniques of the Clanguage. Although written to complement the Guide, it may be used with any introductory text on C.

#### **Developer's Library**

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#### C Programmer's Library

(Purdum, Leslie, Stegemoller, Que Corp.). This best seller is an intermediate text designed to teach you how to write library functions in a generalized fashion. The book covers many advanced C topics and contains many useful additions to your library including a complete ISAM file handler.

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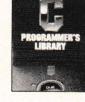
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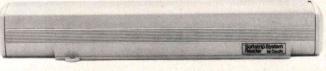
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#### MAKING THE GOOD LIFE EVEN BETTER

Someone once said that there is nothing new under the sun. Wouldn't life be boring if that were indeed true? The data strips on the right contain the program described in the article "The Game of Life in Expert-2", by Jack Park, which appears in this issue. It's a prime example of how something, in this case the game of LIFE itself, can, indeed be improved.

The game of LIFE was invented years ago by John Horton Conway. Over the years, the game has evolved into a popular cerebral exercise for programmers and math majors alike. At first the game was played on graph paper, but the advent of modern technology moved it to the computer which plays the game thousands of times faster. Now millions of computer enthusiasts are captivated by this devilishly simple, yet marvelously complex quintessential computer diversion.

The rules of the game are quite simple. Imagine that you have an infinite grid of squares, each one being either alive (on) or dead (off). Each square (called a "cell") lives or dies into the next cycle (called a "generation") based on its current state and that of its neighbors. The grid of cells is represented by a graphic display on your computer screen. After setting up an initial configuration of living and dead cells, you start the simulation. The patterns will change on the screen as cells live and die.

Mr. Park's improvement on the theme is interesting because of his approach. Instead of writing a traditional program for the simulation, he has created an array of intelligent cells using an inference engine written in Expert-2, a superset of FORTH.

Read in the data strips, following the directions that came with your Cauzin reader. You'll need the Expert-2 programming environment to operate this program. Refer to Mr. Park's article in this issue for operating instructions.

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StripWare Library No. 202

2

3

Softstrip

# Simple Plots with the Enhanced Graphics Adapter

ecently I needed to generate some engineering graphs on an IBM Enhanced Color Display with the Enhanced Graphics Adapter (EGA). I was using a program written in Lattice C Version 2.14 to do the computations, and all I needed was the capability to draw a simple x-y plot, taking advantage of the EGA's 640-by-350 pixel high-resolution mode. An obvious solution would have been to use IBM's Graphics Development Toolkit, but it seemed to be the wrong tool for the job I had in mind.

I assembled my resources. The ROM BIOS video functions (interrupt 10h) came to mind; a quick search of the Lattice C reference manual produced the *int86()* utility function. Armed with these tools, I wrote a set of graphics functions to do my job. Here I present the most interesting of these modules, which set the display in high-resolution graphics mode and perform line drawings.

The EGA can be set up to operate at its highest resolution mode by using the mode number 16 in the ROM BIOS video interrupt. In its basic configuration with 64K RAM, this mode allows four colors. The 640-by-200 pixel resolution of the Color Graphics Adaptor (CGA) can be emulated by using mode number 14.

The BIOS provides a function that allows you to write a pixel; I needed a module that could join two points on the screen. This meant that I had to brighten up a lot of pixels that are close to an imaginary line drawn between the two end points. A tool to help me do this was close at hand—in DDJ, in fact.

The May 1985 issue (#103) contained the article "Using Decision

Nabajyoti Barkakati, 2005 Aventurine Way, Silver Spring MD 20904 by Nabajyoti Barkakati

I needed a module that could join two points on the screen.

Variables in Graphics Primitives" by Tom Hogan, in which the author generalized Bresenham's decision variable method. Bresenham's original algorithm for line drawing is described in the book Fundamentals of Interactive Computer Graphics by James D. Foley and Andries Van Dam (Reading, Mass.: Addison-Wesley, 1982). The algorithm in the book works for lines with slopes between 0 and 1, but can be easily modified to work with lines of arbitrary slope. I have made such modifications in my line drawing function. (See v\_draw in Listing Two, page 74.) Note that I have chosen to represent the lower left corner of the screen as the pixel (0,0), though the upper left corner is considered to be the origin in IBM's ROM BIOS.

In Listing One, page 74, I show a sample program that plots  $\sin(x)$  vs. x on the screen. It's a simple demonstration of the use of graphics primitives. A better way to use the capability would be to write a module that would nicely map the arrays y and x of size n onto the screen. It would first find the true maxima and minima of the data, pick a nicer set of numbers for these extremes, then scale each point onto screen coordinates and use  $v\_draw$  to draw linear segments on the screen to make the plot. A coordinate grid under the plot

would make the output even more attractive. But all this follows naturally once you can connect any two points on the screen, which is what the code presented here permits. I'm sure you wouldn't want me to take away all the fun of setting up your own customized plotting package.

Bresenham's decision variable method, as Hogan explained in his article, can be used to generate any well-behaved curve of the form G(x,y)=0. Hogan's implementation of the algorithm was intended for medium-resolution graphics; Barkakati's interest is with the considerably higher resolution EGA affords.

What Bresenham's method gains you is chiefly speed, an important consideration when doing high-resolution curve drawing. Rather than computing square roots for every point, it depends heavily on integer math. It also creates curved line segments without gaps, a feature that leads to smootherlooking curves. Based on the value of the slope of the tangent line and the direction of its change, the method decides where, in relation to the last point, the next point goes. The slope doesn't have to be calculated for each point; key inflection points merely need to be identified. The slope and how it is changing can be used to select from all possible next points a pair of candidate points and to choose between these-the decision variable part of the approach. At any given location only two next points are reasonable, and the method finds them and chooses between them.-ed.

DDJ

(Listing begins on page 74.)

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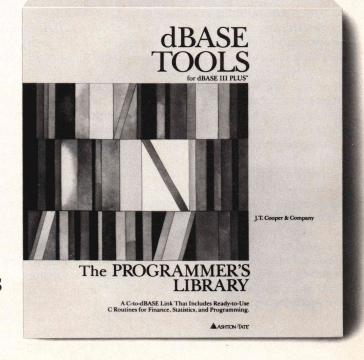
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# A 68000 Cross Assembler—Part 2

ast month I introduced a Modula-2 cross assembler for the Motorola 68000 16/32-bit microprocessor. In that first installment, I looked at the overall structure of the program from a data flow perspective and presented all definition modules as well as the main program module.

This month, I will discuss some of the algorithms used and present all of the implementation modules along with a stand-alone program to initialize the mnemonic lookup table.

Although this project was developed on a Z80 system using the Modula-2 System for Z80 CP/M from Hochstrasser Computing AG, the source code should compile and run on most other small-computer implementations of Modula-2. I will try to identify those areas that may be impediments to portability. The only true machine dependency is because of the assumption that INTEGERS, CARDINALS, and BITSETS all occupy 16 bits in memory. Although not all Modula-2 libraries are equivalent, I have tried to restrict myself to library routines that are common to both the Hochstrasser and the popular Volition Systems compilers. That should allow a fair degree of portability across many different compiler systems.

In Modula-2, the definition module is like a contract. It tells the users of the module (that is, programmers) what tasks will be performed without saying anything about the methods used. Definition modules are compiled separately and provide the only interface to other modules or to the main program module. The definition modules presented last month in-

Brian Anderson, 2977 East 56th Ave., Vancouver, B.C. V5S 2a2 Canada by Brian R. Anderson

In Modula-2, the definition module is like a contrast. It says what tasks will be performed without saying anything about the methods.

dicated the tasks that are to be performed during the execution of X68000; the implementations presented this month describe the algorithms used to accomplish those tasks.

#### LongNumbers

The data type LONG (an array of integers) simulates 32-bit hexadecimal numbers; the implementation module for LongNumbers (Listing Eleven, page 80) provides procedures that input, manipulate, and output the LONG data type.

LongClear simply clears all elements of the array to 0. LongAdd (LongSub) is a multiple precision routine that uses an integer for a carry borrow() flag. The idea is to index through the array, calculating the sum (difference) while checking for any overflow (underflow); such an overflow (underflow) causes the carry borrow() flag to be set and the result to be adjusted. This carry borrow() is then figured into the next digit's calculation.

The conversion routines *Card-ToHLLong* and *LongToCard* use the standard hexadecimal/decimal conversion algorithms, with the addition of range checking. *LongToCard* 

checks the range of the LONG and returns FALSE if any of the four most significant digits are anything but 0. LongToInt is a bit more complicated because there are two possible inrange conditions: either all unused bits must be 0s (positive integer), or all must be 1s (negative integer).

LongInc and LongDec use LongAdd and LongSub respectively, as well as CardToLong, to increment or decrement a LONG data type by any value in the CARDINAL range. LongCompare uses the standard comparison algorithm often used to compare strings.

LongPut and LongWrite cause output of an array of integers as hexadecimal numbers. They both use an internal filter routine called GetDigit to trap integers outside the hexadecimal range. The Size parameter is used to allow LongPut and LongWrite to output only a portion of the number in cases where a small hexadecimal number is stored as a LONG or to output extra long strings of hex digits for the S-records.

StringToLong converts an array of characters into a variable of type LONG. Error checking is done by the ISHEX routine, and GetHEX handles the digit-by-digit conversion. The two address-bounds routines use the set operator IN to force a LONG to specific address boundaries.

#### CmdLin2

I wrote the command line parser (Listing Twelve, page 80) as an experiment: I wanted to see just how flexible the Modula-2 pointer structure really was. My conclusion is that it is just as flexible and powerful as the pointer structure in C and much easier to understand.

This module could not have been written in Pascal because Pascal pointers can reference only variables dynamically created by the standard procedure NEW. Modula-2 pointers can be made to point to any data type.

This routine parses the command line buffer of the operating system, which is referenced by an absolute variable at 80H, into an array of pointers to strings. (Absolute variables are another new feature of Modula-2 and allow any variable to be placed at a specific location in memory.) The parsing is done without even recopying the buffer by setting a pointer to the beginning of each argument and a null terminator at the end (replacing the space that normally separates command line arguments). After all arguments have been so processed, ArgV is set to point to the pointers. (See Part 1 of this series of articles for a description of how the pointer is used to retrieve the arguments—C programmers will feel right at home.)

The CmdLin2 implementation uses a looping construct that is new to Modula-2: LOOP . . . END. This construct has two useful variations: the first is an infinite loop; the other, by using the optional EXIT statement, allows termination anywhere in the loop even allowing multiple terminations. I know of one university instructor who asks his students to prove that WHILE or REPEAT are inappropriate before they are given leave to use the LOOP. Some authors refer to it as an unstructured loop. I tend to agree, instead, with Donald Knuth, who feels that all constructs-even the lowly GOTO-have an inherent structure; if that structure matches the structure of the problem, that's the one to use.

In CmdLin2, there are three EXIT statements in the LOOP . . . END statement. I went through many trials using WHILE and REPEAT, extra Boolean variables, and all the usual so called structured "tricks," but none were as clear and simple as the LOOP (yet still reliable under all conditions of input).

While reading through a Modula-2 textbook recently, I came across several examples of a small program fragment that was supposed to read integers and add them to a sum and then stop when something other than an integer was read. All three of the examples given either used two read statements, tested the same condition twice, or both. These were supposed to be examples of the correct way to use WHILE and REPEAT loops but were a perfect example of trying to shoehorn the problem to fit the structure. Such examples appear repeatedly in programming texts.

Modula-2's LOOP ... EXIT ... END construct provides a simple and elegant solution:

- (\* ReadInt and Done are imported
- (\* from the standard module InOut \*)
- (\* Done is set TRUE if ReadInt
- (\* is successful.

sum := 0; LOOP ReadInt (num); IF Done THEN sum := sum + num;ELSE EXIT;

#### Parser

END:

END;

The name for this module is really a bit of a misnomer because all it does is split up the 68000 source code into its components: LABEL, OP-CODE,

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68K ASSEMBLER (continued from page 45)

SOURCE-OPERAND, and DESTINATION-OPERAND (Listing Thirteen, page 80). The algorithm is quite primitive in that it merely scans the line from left to right looking for the various parts and transfers them into variables called Label, OpCode, SrcOp, and DestOp. These variables are arrays of characters defined in the definition part of this module. The location of each item is noted for later use in the

error handling module so that the exact location of any error can be pointed out.

The most convoluted part of the scanning process is picking out delimiters, especially when the normal delimiter characters get imbedded within parentheses or quotes. The problem is handled by a couple of flags. *ParCnt* keeps track of (possibly nested) parentheses counts, and *InQuotes* becomes *TRUE* inside quotes; both are used to prevent incorrect detection of delimiters. Parser will

flag an error if any identifier or expression is too long. Labels and opcodes are limited to eight characters, and operands (including expressions) are limited to 20 characters.

#### SymbolTable

The implementation of this module (Listing Fourteen, page 84) hides a data type called SYMBOL and variables called SymTab, Top, and Next. This is an excellent example of the way Modula-2 allows you to separate lifetime and scope. These variables must exist during the entire time that the program is running, as they pass on information gathered in assembly pass 1 to assembly pass 2. Yet, at the same time, you don't want any access to these variables except through the symbol table routines. To allow Pascal variables to exist for the life of the program, they would have to be declared as global, at the risk of side effects from unplanned access. Modules provide a visibility wall between their contents and the rest of the program. SymTab, Next, and Top cannot be accessed from outside SymbolTable (limited scope), but they exist for the life of the program (global lifetime).

The FillSymTab routine simply adds a SYMBOL (a record consisting of an identifier and a LONG number) to the next open position in SymTab and returns an error if no room exists. SortSymTab uses a Shell sort to place the identifiers in alphabetical order for easy access. Notice in the Swap routine that entire records can be assigned in one statement in Modula-2. Not only is this more convenient than assignment one element at a time, but it is also more efficient: The compiler is able to use fast and compact assembly-language routines to copy the data into the new variable.

ReadSymTab uses a binary search to find quickly the value associated with any identifier. If the symbol is not found, ReadSymTab returns FALSE to the calling program. It is here, also, that duplicate symbol table entries are flagged (to do it in Fill-SymTab would require sorting and searching the table after each entry—which is hardly worth the extra time!).

ListSymTab really only returns one entry in the table and is used by the Listing module to provide a sym-

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bolic reference table of identifiers at the end of the program.

#### **OperationCodes**

X68000 is a "sort of" table-driven assembler (I'm gonna get lots of objection to this one!). The mnemonics and data that are used to derive the opcode bit patterns and all addressing mode information come from a file called OPCODE.DAT. This file must exist on the default disk any time X68000 is run because the data must be read into the lookup table used in the binary search routine to find the instructions. X68000 is not a true table-driven assembler because it lacks the flexibility to accept tables of various processors and the table (OPCODE-.DAT) is not a text file.

In Modula-2, implementation modules may optionally specify an initialization part. This initialization is run on program start-up, before the main program runs. The purpose is to set initial conditions within the module. The initialization for OperationCodes (Listing Fifteen, page 86) opens the file OPCODE.DAT, and reads the data into an array called Table68K. This data file is stored in compact binary format. Instructions is the only routine in OperationCodes; it uses a binary search routine to find the correct mnemonic opcode in Table68K. If found, its bit pattern, as well as two SETs consisting of (enumerated) addressing modes, are returned to the calling program. If the opcode mnemonic is illegal (that is, not found), an error is flagged by the error handling routine in ErrorX68.

#### InitOperationCodes

This program module (Listing Sixteen, page 86) is not actually part of X68000 but merely creates the data file OPCODE.DAT described above. It contains most of the same declarations and definitions that Operation-Codes contains as their data types and variable have to match exactly.

The lookup table for the mnemonics is created by this program one mnemonic, bit pattern, and addressing mode at a time. There are 118 mnemonics (ABCD to UNLK), and each is assigned one element of an array. Each element of the array is a fourfield record. After data is assigned to the array properly, it is written to a disk file using the WriteRec procedure.

Note: The WriteRec procedure may not be available on all implementations of Modula-2 but may be added easily by the programmer. It makes use of the generic parameter type WORD. Two possible implementations are:

For machines, such as the PDP-11 and many microcomputers, in which TSIZE(WORD) = 2:

WriteRec (f: FILE; Rec: ARRAY OF WORD);

i: CARDINAL;

ptr: POINTER TO CHAR;

**BEGIN** 

ptr := ADR (Rec);

FOR i := 0 TO HIGH (Rec) DO

Write (f, ptr^);

INC (ptr); (\* move

pointer to next byte \*)

END;

END WriteRec;

For machines where TSIZE(WORD) =1 and a WriteWord procedure exists:

WriteRec (f: FILE; Rec: ARRAY OF

WORD);

VAR

i: CARDINAL;

**BEGIN** 

FOR i := 0 TO HIGH (Rec) DO WriteWord (f, Rec);

END WriteRec:

Similar routines can be developed for reading records, as required by the OperationCodes initialization.

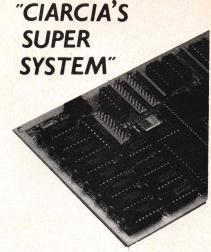
Some libraries provide procedures to read or write multiple bytes to a file. These usually require the location (an address) and size (in bytes) of the record. In this case, Modula-2's low-level facilities may be used to read or write the record:

WriteNBytes (f, ADR (rec), SIZE (rec));

#### **CodeGenerator**

This module (Listing Seventeen, next month) does more than is suggested by its name. The definition module of CodeGenerator lists three procedures: BuildSymTable, which "generates the code" for pass 1 (that is, feeds the symbol table); AdvAddrCnt,

Byte Magazine called it.



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# 68K ASSEMBLER (continued from page 47)

which increments the address counter after each instruction is analyzed (used in both passes); and *GetObject-Code*, which (with the help of many other procedures in CodeGenerator and SyntaxAnalyzer) figures out the machine code and returns it to the

main program as three LONGs. I will (as far as possible) try to present the procedures in the order that the code would pass through them during assembly. This will mean some references to SyntaxAnalyzer, as these modules are tightly coupled and are used in both passes.

BuildSymTable is used only during pass 1, and, as was mentioned above,

it is involved with creating the symbol table. It does nothing (returns immediately) if there is no opcode. The cascaded *IF ELSIF ELSE* statement determines, first, if any assembler directive is present, and if so, specifies the amount of memory reserved (that will vary—EQU reserves no memory, whereas *DS* may reserve any amount). Next, if there is any la-

## **Modula-2 Porting Experience**

#### Background

Modula-2 is a relatively young language, and efforts to standardize both the basic language and the library are still underway. Modula-2 was developed at the Swiss Federal Technical Institute (ETH) in the late 70s by a team headed by Niklaus Wirth, the creator of Pascal.

The original language definition was contained in Programming in Modula-2 by Niklaus Wirth, 2d ed. (New York: Springer-Verlag, 1983). On March 3, 1984, Wirth released a brief entitled "Revisions and Amendments to Modula-2," which outlined several clarifications, revisions, and extensions to the language itself. This brief was published more recently in the January/February 1985 issue of The Journal of Pascal, Ada, & Modula-2; the changes have also been incorporated into the third edition of Wirth's book. Most microcomputer compilers have not yet implemented these changes or have implemented only some of them.

The library, too, exists in several versions. In his original work, Wirth postulated a standard minimum library-much of it for the DEC PDP-11 minicomputer. Since then, a much more extensive library has been developed for the Lilith, the Modula-2 bit-slice microcomputer developed at ETH. One of the earliest (popular) microcomputer implementations of Modula-2 was by Volition Systems, which produced compilers for several computers including the Apple II, IBM PC, and Sage. Several textbooks have been based on Volition Systems' compiler and library, including those by Gleaves, Wiener and Sincovec, Wiener and Ford, and Knepley and Platt. Finally, the Modula User's

Society (MODUS) has been working on what it hopes will be a universal library.

#### **Porting Among Systems**

By and large, the compilers themselves are pretty much compatible (despite the amendments mentioned above). Virtually all microcomputer implementations use 16 bits for CAR-DINAL, INTEGER, and BITSET data types: most implement strings as NULL terminated ARRAY OF CHAR. (Interface Technologies' is the only product I know of that implements strings Pascal-style-presenting a serious impediment to portability.) All the standard data types, structures, loop constructs, and operators are invariably provided. Some compilers omit or alter the low-level facilities for concurrent processing, but most programmers will have limited use for these advanced features.

Differences in the library, particularly in file handling, are where most of the problems lie. The four systems I am familiar with (those from Hochstrasser, Volition Systems, Interface Technologies, and Logi-Tech) have three significantly different approaches to files. Hochstrasser's and Volition Systems' are essentially similar and follow the earlier (PDP-11) work at ETH; Logi-Tech's follows that for the Lilith quite closely; whereas Interface Technologies' seems to go its own way. On the plus side, all implementations provide the high-level I/O modules suggested by Wirth (Terminal and InOut) as well as the the floating-point library (MathLib0). Most provide essentially similar conversion libraries for changing strings to numbers and vice versa.

#### Porting X68000 from Hochstrasser (CP/M) to LogiTech (MS DOS)

Hochstrasser supplies several filehandling modules with its compiler. I chose to use the one called Files because I knew it to be nearly identical to a module of the same name supplied by Volition Systems. The Files module is flexible and powerful in that it allows random or sequential access; it also provides methods to read or write complete data structures. LogiTech supplies one file-handling module-FileSystem, which is capable of all the same operations as is Files, along with text-oriented streams (supplied as a separate module called Texts in the Hochstrasser and Volition Systems libraries).

The first (and easiest) step in porting to a new compiler is to change the names of the various procedures to match the new library. In this instance, for example, Read became ReadChar, whereas WriteRec (f, RecordVariable) had to be converted to WriteNBytes (f, ADR (RecordVariable), TSIZE (RecordVariable), Written). All these kinds of changes are obvious from reading through the documentation of the compiler systems, and they present few problems.

Several of the necessary changes are not so obvious. Both systems supply a Create procedure, which (as the name suggests) is for creating a new file. LogiTech's system, however, creates only a temporary file, which disappears as soon as the file is closed. To open an existing file, Hochstrasser supplies the procedure Open and LogiTech supplies Lookup. Lookup is a general-purpose procedure that, depending on a BOOLEAN parameter, will either open an existing file or create a new one. Because the assembler must often create a new version of an existing object file, I found it necessary to call Delete before using Lookbel present (whether there was an assembler directive or not), an entry is made in the symbol table. That entry will consist of the current value of the address counter except in the case of the *EQU* assembler directive.

Notice that an error due to a full symbol table will be detected here this is a fatal error and will cause the assembler to abort. You must then split up your program into two or more modules. If there was no assembler directive (pseudo-op), Get-Operand and GetInstModeSize (procedures from the SyntaxAnalyzer module) help to determine the size of the operands. The special QUICK mode instructions must be taken into account before determining how far the address is going to have to be ad-

vanced by this instruction.

During pass 2, GetObjectCode first checks if there is any opcode, and it returns without doing anything if there is none. After making note of the size extension of the opcode, control is passed to ObjDir, which handles code generation for assembler directives (see detailed description later). Phase errors are checked by com-

up to create a new file.

The Hochstrasser Files module implements the type FILE as an opaque (hidden) type (that is, as a pointer to some structure defined in the implementation module). The opaque type FILE allows the programmer to use files with no knowledge of their underlying structure. LogiTech's system, taking the same approach as that for the Lilith, implements type FILE as a record that is specified in the definition module. This forces the programmer to know the intimate details of the file structure and also has one very (for me at least) unexpected and disturbing consequence: The type FILE must always be passed as a VAR parameter. If it is passed as an ordinary value parameter (as can be done with the opaque pointer type), the calling program is unable to get information back to the FileSystem module, resulting in rather odd run-time errors. It took quite a bit of head scratching to puzzle that one out. With all the changes in place, the file systems on the two versions of X68000 produce outwardly identical results.

LogiTech's compiler passes all command-line parameters to the first ReadString call in the main program, which obviates the need for my CmdLin2 procedure. From the user's perspective, the effect created is essentially similar: The assembly file name can be entered either as the program is invoked or in response to a prompt once the program has started

The number conversion routines supplied by the two compilers differ both in name and in behavior. In one case (CARDINAL to STRING), I had to add an extra parameter (specifying length), whereas in another (STRING to CARDINAL), the behavior of the equivalent LogiTech procedure was sufficiently different that I had to write a new conversion routine.

## Other Factors Not Related to Portability

At the college where I work, one of my colleagues has dubbed the IBM PC "Miss Piggy" for its propensity to gobble up memory. It seems that with every application you care to name, the PC requires much more memory than does any other computer. Compilers are no different in this regard.

The original work on X68000 was done on a standard CP/M system with 64K of memory and two 1.2-megabyte floppy-disk drives. When I started work on the port to the MS DOS environment, I tried using a standard IBM PC with 256K of memory and two 360K floppy-disk drives. I soon found that the standard PC was not up to the task.

Upon moving to a machine equipped with a 20-megabyte harddisk drive, I was able to start compiling, and all but two of the modules would compile. On the InitOperationCodes module, the compiler aborted with an "out of memory" error. This was the program module that initialized the mnemonic lookup table, and then wrote it to a file-it was impractical to split it into several modules. The only solution was to expand the memory to 512K. Even with the extra memory, however, an implementation restriction still prevented several of the procedures from compiling because they were too long. Remember, this is the same code that compiled without a whimper on a 64K CP/M system. Eventually I had to split the InitOperationCodes main program into four procedures and also split the MergeModes procedure (from the CodeGenerator module) into four. Despite the length of these procedures, splitting them made no sense from the point of view of program logic.

The Hochstrasser compiler does no

error checking at run time, whereas LogiTech's checks for integer/cardinal overflow, array range errors, CASE out of range, and so on. It seems that all the type transfers used in X68000 cause some range errors because, before I could get the program to work, all the error checking had to be turned off. This is easily done with the LogiTech compiler (via compile-time option switches), and it causes no problem whatever to the accuracy or internal error checking done by X68000.

Just out of curiosity, I timed the compilers on several large modules. Both compilers use four passes, which are overlayed from the disk. The Hochstrasser linker produces an executable file directly, whereas LogiTech's requires an additional step for this. Even with the hard disk and 512K installed on the IBM PC, the LogiTech compiler was only about 20 percent faster than was the Hochstrasser compiler.

#### The Verdict

Porting X68000 to the IBM PC using the LogiTech compiler was a relatively painless and quick process. The total time expended was roughly 15 hours—much of which was spent getting used to a new compiler. If you are already familiar with your compiler, you should have little trouble making the conversion in a single afternoon.

True to form, the compiled code is 47 percent larger on "Miss Piggy" than it is on the CP/M system. Execution speed (of X68000) is essentially the same on the CP/M and MS DOS versions.

#### 68K ASSEMBLER

(continued from page 49)

paring the pass 1 address count (from the symbol table) with the pass 2 address count for any line that has a label. The two instruction types that use relative addressing modes are handled as a special case because of the odd requirements placed on them. (There is no automatic selection of the most efficient branch length. The assembler assumes the worst case and produces long branches unless explicitly told to use the short

form. Full range checking is done for either long or short branches, however.) Object code for the balance of the instructions is produced in Merge-Modes (described next).

Although the 68000 instruction set is very orthogonal (regular), there are a few instructions that have to be handled as special cases. That is the purpose of the CONST definitions at the top of the module: they are BIT-SET constants representing several operation codes. These are used within the MergeModes procedure to take care of the special cases before the more common addressing modes are handled.

MergeModes is not exported from the definition module of CodeGenerator but is used by the GetObjectCode procedure to combine information from several sources to produce the hexadecimal machine code. Merge-Modes is at the heart of the code generation process. Many 68000 instructions use a format that is some variation on ADD Dn. <ea>. The effective address <ea> may be any of 12 addressing modes, although few instructions use all 12 modes. There are four basic groupings of these modes-Data, Memory, Control, and Alterable—which may be combined in various ways. The local procedures EffAdr and OperExt determine the bit patterns needed for the effective addressing mode being used along with any operand extension needed for that addressing mode. (For example, MOVE D3,600(A2) requires that bit patterns of 000011 and 101010 be inserted into the opcode for the source and destination operands, and an extension word of 0000001001011000 needs to be tagged on after the opcode for the 600 offset.)

The bulk of MergeModes crosschecks the addressing mode found by GetOperand with the modes that are allowed for the current instruction (information from OPCODE.DAT and the OperationCodes module). Any errors are passed onto the ErrorX68 module, where verbal error messages are displayed on the console. If no errors are detected, various bits and pieces of information are combined to produce the machine code for the instruction.

An example will illustrate typical operation for the complete sequence needed for code generation. This comprises two steps: first converting the source code to an intermediate language consisting of sets, enumerations, and various integral values; and then combining the elements of this intermediate language into Motorola 68000 machine language.

ADD (A2),D6 ;Add the data word addressed by A2 ;to data register D6

When the Parser module is finished with this instruction, you are left with three character strings: ADD,

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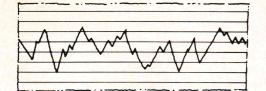
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68K ASSEMBLER (continued from page 50)

(A2), and D6. Parser passes ADD to OperationCodes, which returns three sets: {15, 14, 12} --> 1101 0000 0000 0000, ModeA{OpM68D}, and Mode-B{EA05y}. The first set is the raw bit pattern for this instruction—that is, the bit pattern without operand-size bits and operand addressing-mode bits added. The other two sets specify the addressing modes that the ADD instruction can use and are designations internal and unique to X68000.

The Parser passes (A2) and D6 to the *GetOperand* procedure in SyntaxAnalyzer (through CodeGenerator), where they are analyzed. A record of type *OpConfig*, which contains the mode, value, size, and various other information, is provided for each operand. In this example, those records would contain the following data:

(A2) Mode ---> ARInd

register indirect;

Value ---> none

Loc --- location on source line

Rn ---> 2

Xn ---> none

Xsize ---> none

Xtype --> none

D6 Mode --- > DReg ;data register

Value ---> none

Loc --- location on source line

Rn ---> 6

Xn ---> none

Xsize --> none

Xtype --- > none

MergeModes will take all pertinent information from the above to produce the machine code or, if there are inconsistencies, produce error messages.

An IF statement checks for each of the possible addressing modes. For example, the IF OpM68D IN AddrModeA statement would be used for the ADD (A2), D6 instruction because ADD resulted in ModeA{OpM68D} being returned from OperationCodes. The Dest. Mode is checked to see that it is DReg (it is), so the Dest.Rn (6) is shifted left by 9 and ORed with Op. Because shift left is not provided in Modula-2, I used multiplication to accomplish the same thing (multiplication by 2 is the same as shift left 1). Because of a principle called strength reduction, this multiplication (by a power of 2) is not nearly as inefficient as you might think. As part of this same *IF* statement, the size bits are *OR*ed into place depending on the size suffix placed on the instruction.

Because there is no size suffix on ADD (A2),D6, size WORD is assumed. The IF EA05y IN AddrModeB will fill out the operation with more error checking and a call to the EffAdr local procedure mentioned above. This procedure checks that the mode used is consistent with the instruction, then uses bitwise AND/OR to append the correct bits. OperExt would have nothing to do on this instruction because neither ARInd or DReg require an operand extension.

All instructions follow a similar format: source line ---> line parts (label, opcode, operands) ---> intermediate language (bitsets, enumerations, and so on) ---> machine code. Any or all of the processes involved in reaching these states can result in error messages if the source line does not conform to correct 68000 syntax.

The hidden procedure ObjDir is the assembler directive equivalent to MergeModes—it produces the code for the directives. It is essentially similar to the cascaded IF ELSIF ELSE statement that handles pseudo-ops in the BuildSymTable routine except that it has to generate the code, which means determining values and setting object code lengths. This procedure also handles ASCII strings. I'm not at all satisfied with this section of code, and if you think it looks like an afterthought, you're right! The awkwardness results from having to pass the string (which is converted to LONG) to the output modules as a 2-byte opcode and two 4-byte operands. The other alternative was a major rewrite, which will have to wait until Version 2 (when I will have to rewrite some of the code to accommodate a linker, anyway).

#### SyntaxAnalyzer

The procedures within SyntaxAnalyzer (Listing Eighteen, next month) are not visible to any other module except CodeGenerator (it was originally part of the same module). Its purpose is mainly to analyze the operands of the instructions and to determine their value and their mode.

CalcValue and GetValue work to-

gether, as their names suggest, to determine the value of any operands that have a value. These include decimal numbers (0-65535); hexadecimal numbers (0-\$FFFFFFF); single quoted ASCII literals; the symbol for the current value of the program counter (\*); and identifiers, which may represent any value. GetValue contains a simple left-to-right expression evaluation loop that recognizes only addition and subtraction operations. It hardly has the elegance of a recursive descent expression parser, but it is simple and compact. GetValue uses the LOOP ... END construct with three conditional EXIT statements. Although this could have been done with a REPEAT loop, the termination condition would have been awkward, with six terms, three ANDs, and three ORs. I rest my case!

Two procedures, called GetSize and GetAbsSize, determine the size of operands (BYTE, WORD, or LONG) by looking for a suffix of .B, .W, or .L. If no suffix is present, size WORD is assumed, as required by the Motorola syntax. The GetAbsSize procedure actually creates a slightly nonstandard syntax for this assembler. Most 68000 assemblers will automatically choose the WORD absolute addressing mode for addresses in the ranges of 8000-0 and 0-\$7FFF and LONG absolute addressing for higher addresses. X68000 will always use full 32-bit addressing unless specifically instructed to do otherwise. The syntax is nonstandard MOVE D0.\$6000.W.

The GetInstModeSize uses a CASE statement to return the size of the object code, both in terms of address count and in terms of number of hexadecimal digits required.

GetOperand is the workhorse of SyntaxAnalyzer, as it is responsible for performing lexical analysis on the rather complex and varied operands used in 68000 assembly language. Not much elegance here—this routine simply looks for all the possible addressing modes. When it finds a good one, it returns all necessary information in the form of the record described above under Code-Generator. If GetOperand finds an impossible addressing mode or an out of range register number, it uses ErrorX68 to report the error to the user console.

GetMultReg is a routine that sorts out the MOVEM instructions. This instruction is like a multiple PUSH or multiple PULL operation. MOVEM D0-D7/A0-A6,-(SP), for example, will push all 68000 address and data registers onto the stack with one instruction. This is accomplished by a mask that follows the actual instruction, where each bit in the mask represents a register; if the bit is set, that register gets moved. The job of Get-MultReg is to produce that mask from the register list. The - indicates a range: D0-D7 means all registers between D0 and D7 inclusive, and the / is just a separator. My strategy was to use a flag and an enumeration type along with nested IFs to keep track of what state the calculations were in. That made it easy to detect errors because it would cause a transition to an illegal state. Just to complicate matters, the mask has to be inverted in certain cases. That function is taken care of by a conditional subtraction as the mask is constructed.

#### Listing

The Listing module (Listing Nineteen, next month) creates the formatted program listing with object code and source code together in the usual format. The StartListing procedure does nothing but print a heading and initialize the page count and line count variables. WriteListLine does what its name implies-writes one line of listing to the file. Unused object code fields will be skipped automatically (no address is entered in the case of an EQU pseudo-op, for example). The LongPut routine from LongNumbers is used to write all object code (in hexadecimal) to the file.

Modula-2 file libraries do not usually contain any way to write a string to a file (InOut and Texts allow this, but that's another story), so I had to write a small procedure to do that. The WriteStrF outputs any string to a file and is used throughout Listing.

The WriteSymTab procedure uses information imported from the SymbolTable module via ListSymTab to output a symbolic reference table at the end of the listing. ListSymTab will return the nth entry in the symbol table each time it is called. Both WriteListLine and WriteSymTab make use of a procedure called CheckPage to form-feed to the next

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# 68K ASSEMBLER (continued from page 53)

page and print a new page number. The listing file created by this module may be dumped to a standard printer with the *PIP* command.

#### Srecord

Creation of S-record files (Listing Twenty, next month) is a bit more complicated than creation of listing files. Count and checksum bytes must be calculated, and it is usual to split the source code into equallength records unrelated to the length of the 68000 instructions (that is, some instructions may be split with half on one line of the file and the rest on the next line).

My strategy in this was to accumulate source code until there was enough to output a 16-byte record, output that record (saving any extra bytes accumulated for the next record), then go back to accumulating more. This necessitated two storage arrays and two indexes for accessing them: Sdata/Sindex and Xdata/Xindex. Another complication is that re-

cords should start on boundaries divisible by 16 whenever possible. Only three procedures are exported from the definition module of Srecord: StartSrec, WriteSrecLine, and End-Srec. Several other procedures that are hidden within the implementation module do much of the work.

StartSrec creates the S0 (header) record. This record consists mainly of the source file name as ASCII characters represented in hexadecimal format. However, all S-records must have an address (this is always 0 for the header record), a byte count, and a checksum. The byte count includes a count for the address and the checksum; the checksum is the complement of the 1-byte residual of the sum of the address, count, and data.

The WriteSrecLine procedure returns immediately if there is no address to write out (this occurs on blank source lines or for EQU statements only). Next, Xdata is transferred to Sdata if there was anything left over from the previous call to WriteSrecLine. If for any reason the address count passed into WriteSrecLine is different from the internal count, any existing data is output as a complete S-record, and a new record is started. This would occur any time a new ORG statement is encountered in the source code. Finally, each of the ObiOp, ObiSrc, and ObiDest (object code for opcode, source, and destination, respectively) are appended to Sdata. If Sdata now contains more than 16 bytes, the record is written out to the file (this is detected by AppendData, returning FALSE). Any excess object bytes are retained in Xdata.

The information in Sdata and Xdata is retained between calls to WriteSrecLine because these variables are declared within the module (not within a procedure). These variables cannot be seen outside the Srecord module (local visibility) but remain in existence throughout the lifetime of the program (global existence). In Pascal, lifetime and visibility are tied together: If a variable exists, it is visible; if it is not visible, it no longer exists. That prevents local variables in Pascal from retaining values between calls—a very useful feature, as illustrated here.

The EndSrec procedure outputs any data left over from the final call

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to WriteSrecLine and then outputs a fixed S8 trailer record.

Actually, this even-boundary and consistent-length business is not required by the S-record format because each S-record is totally autonomous in that it begins with both its own starting address and a byte count. It is traditional for Motorola Srecords to be formatted as described above, however.

#### ErrorX68

Most error handling (except that involving files) is done by the ErrorX68 module (Listing Twenty-One, next month). This module defines an enumeration type that provides 12 named error types. The procedure Error outputs the line count (source line where the error was found), the source line itself, an arrow pointing to the error, and a verbal error message. The program is then suspended until the operator acknowledges the error by pressing any key on the console keyboard. If greater than 500 errors occur, the program is terminated with an appropriate message. After pass 2 is completed, WriteErrorCount outputs an END OF ASSEM-BLY message to both the console and the listing file.

#### Compiling X68000

Because many of the modules within X68000 interact in complicated ways, the order of compilation is critical. Specifically, if ModuleA imports objects defined in ModuleB, it is clear that ModuleB must be compiled first. In all cases, a definition module must be compiled before its implementation module can be compiled; how-

#### Compilation Order for X68000

- 1. CmdLin2.DEF, CmdLin2.MOD
- 2. LongNumbers.DEF, LongNumbers.MOD
- 3. Parser.DEF
- 4. CodeGenerator.DEF
- 5. SyntaxAnalyzer.DEF
- 6. SymbolTable.DEF, SymbolTable.MOD
- OperationCodes.DEF, OperationCodes.
- 8. Listing.DEF, Listing.MOD
- 9. Srecord.DEF, Srecord.MOD
- 10. ErrorX68.DEF, ErrorX68.MOD
- 11. Parser.MOD
- 12. SyntaxAnalyzer.MOD
- 13. CodeGenerator.MOD
- 14. X68000.MOD

#### Table 1

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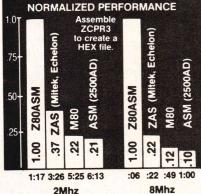
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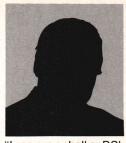
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# 68K ASSEMBLER (continued from page 55)

ever, it goes further than that. The definition module of Parser, for example, defines two types (TOKEN and OPERAND) that are used in SymbolTable, CodeGenerator, SyntaxAnalyzer, and others. Therefore, Parser.DEF must be compiled before any module that depends on it. If the correct order is not followed, the compiler will produce "undefined identifier" errors. Many similar situations exist in any nontrivial Modula-2 program.

The compilation order shown in Table 1, page 55, avoids any problems but is not the only possible ordering arrangement. (A harmless circular reference exists between Parser and ErrorX68 because each imports objects from the other. This only affects the order of execution of their respective initialization parts and causes no problems of any sort.)

#### **Modula-2 Design Strategy**

The implementation module often hides details not apparent in the definition module. Obviously, the algorithm is encapsulated inside the implementation module, but it goes further than that. Constants, types, variables, and procedures that are not visible from the definition module may contribute an important part to the module's function. (For example, the GetDigit, IsHEX, and GetHEX routines from LongNumbers as well as the LineParts procedure from Parser are unknown to the definition modules, and hence they need not be known by any programmer using these modules.)

Additionally, the module initialization may play an important role in the structure of the program, as in the SymbolTable module when SymTab is cleared and the indexes for access to the table are set to their starting points or as in OperationCodes where data is brought in from a file. Finally, modules may be used to control visibility and lifetime fully: Nothing is visible outside a module unless it is exported, but variables belonging to library modules exist throughout the life of the program. These features allow large programming projects to be constructed of modules of only a few closely related procedures. Debugging is easier, and maintenance is

finally possible!

#### Conclusion

Although X68000 is a fully functional program, I do not consider it a completed project as several areas could use improvement. Expression and string evaluation should both be improved. The first steps would be to expand and improve LongNumbers to include multiplication and division and to improve efficiency. This can wait until Modula-2 compilers conform to the new standard and add long integer and cardinal data types. Constant strings should be expanded to at least 80 characters per line. That is harder than it sounds because of the way parameters are passed to the Listing and Srecord modules.

Finally, there is the matter of a linker. To adapt the assembler to provide relocation information will require some rewriting of existing code and some new code; however, many of the modules could be reused almost intact. Then there is the Linker

itself—not a trivial task either. If any readers have further suggestions on how X68000 can be improved, please pass them along to me. Better yet, make the changes yourself and hand the program back into the public domain in improved form.

#### Availability

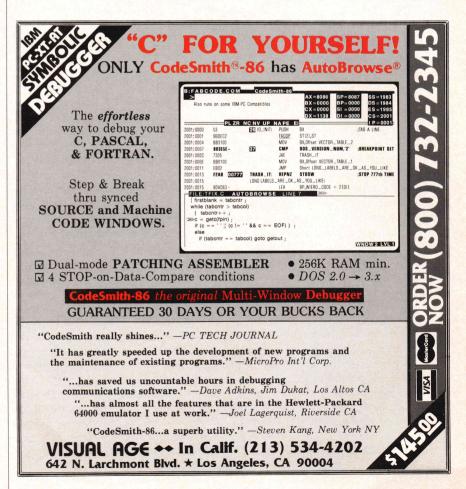
The following is available directly from the author for \$20 (U.S.):

- 1. A 25-page X68000 *User's Manual* that includes operating instructions for the program as well as a description and example of a method to use the assembler to link several modules.
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(Listings begin on page 80.)

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# The Cryptographer's Toolbox

he "Infinite Key Encryption System" article in the August 1984 issue of DDJ contains an excellent tutorial on encryption systems. At the time it was published, I read it with only passing interest, but about six months ago, I developed a need for this type of utility and so begins my story. The first thing I did was write a shell cypher program (cypher.c-Listing One, page 94). Because I had already written a generic file copy utility that allowed modifications during transfer, it was a simple matter to modify the argument passing to include multiple keys and add a cypher() function call to encrypt the file with a simple exclusive-ORing algorithm (cypher1.c-Listing Two, page 94). Although this method did encrypt the file and allowed for easy decryption (using the same run string), there were definite detectable patterns in the resultant file. These patterns, a function of the key period, were easily found in areas of repetitive characters (for example, a string of asterisks or spaces). Another drawback to this scheme was the inability to pass nonprintable characters in the run string, thereby limiting the number of encryption tokens. So, it was back to the drawing board.

Rereading the aforementioned article with renewed interest, I gained an insight into the methods and schemes of practical modern cyphers. I don't intend to cover these concepts, so if you're interested avail yourself of that article and those in

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The strongest cypher schemes use a combination of transposition and substitution.

its bibliography.

Although the article's tutorial portion was excellent, I disagreed with a few points on implementation. First, there was the code itself and the intimation that assembly language was required for reasonable speed. The MAC Assembler is used only with CP/ M-80, and I wanted more portable source, so I decided to write it in C. Second, I felt that a random key of some prime length could be generated solely from the original key (cypher2.c-Listing Three, page 95). Although some keys may work better than others, a means to evaluate results can render this method functional. And last, I disagreed with the need for passing information in the encrypted file. It seemed unnecessary and cumbersome. My goal was to develop a method that worked entirely from the run string. Overall. though, I must commend the work done by John Thomas and Joan Thersites for presenting such a complete treatment of their topic.

#### The Ultimate Cypher

The ultimate cypher is like the ulti-

mate weapon—no matter how sophisticated, an antiweapon (anticypher) can be developed eventually if there is a need. The user must make some judgments regarding needs and level of protection. The two algorithms mentioned above are relatively simple to implement and use. The same keys can encypher or decypher the file, and key order isn't important.

The experts (and it becomes quite obvious) point out that the strongest cypher schemes utilize a combination of transposition and substitution. When transposition is added however, the order of decyphering must be the exact reverse of encyphering. The last cypher module contains an algorithm for transposing the file tokens along with the random generated key encryption scheme (cypher3.c—Listing Four, page 95). This is a small price to pay for the added security.

#### The Need for Tools

As I progressed in my quest for the ultimate cypher/decypher algorithm, I became aware of the deficiencies of the standard CP/M utilities at my disposal, so I developed my own.

The first tool, fv.c (Listing Five, page 97), replaced my CP/M dumpcom. Dump provides a continual onscreen display of the hex contents of a file. Because most encryption is performed on text files, it is beneficial to include the ASCII form along with the hex. And, because most algorithms use an exclusive-OR as the means of encryption, it is easy enough to dump two files and the exclusive-ORed difference between them.

The next tool, fstat.c (Listing Six, page 98) calculates and displays the statistical characteristics of the file. This tool scans the file, counting the occurrences of each element, and provides a 16 × 16 display of the distribution of characters. It calculates mean, median, mode, and range of the character distribution and displays its histogram. As you might suspect, each file type has a definite signature. In fact, after limited use of this utility, you will be able to recognize the histogram patterns for text, WordStar, and many other files.

While experimenting with various schemes, it became obvious that the most difficult file to disguise was one that contained a single byte for every entry or some sequential scheme. So, the next task was developing a utility, makef.c (Listing Seven, page 100), to generate a known sequential or unicharacter file of some user-defined length.

Finally, the last utility, sp.c (Listing Eight, page 100), was a search scheme I needed to look for repetitive patterns occurring within a file and to provide some information regarding location and depth of the repetition. It also includes the option to calculate the delta characteristics of a file to search for repetitive mathematical as well as character sequences.

#### Cypher.c—Listing One

The cypher shell program is provided for use "as is" or for user modification. It contains the argument-passing and file-handling source code needed to copy from an existing file to a new file via a 16K buffer, with a cypher function being called to encrypt the file. (If the file is less than 16K, the input file name may be the same as the output thus destroying the original contents.) I chose a 16K buffer because it should fit easily with most compilers. This value may be adjusted to meet individual compiler needs.

Any of the three algorithms that follow may be included or linked with this shell. Caution is recommended to ensure that the function name is appropriate for the method you use. The keys are passed in the CP/M command line and therefore are limited by its length as well as the argument-passing capability of the C compiler.

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## CRYPTOGRAPHER'S TOOLBOX (continued from page 59)

#### Cypher1.c—Listing Two

This minimal cypher algorithm uses an exclusive-ORing scheme to encrypt the file with the keys passed. If the user employs keys of some prime length and performs multiple passes, the results can be quite difficult to decypher. Because the keys are limited to include only printable characters, you don't take full advantage of the 256 codes available for a byte.

#### Cypher2.c—Listing Three

Now something a little more difficult for the code breaker, an algorithm that grew out of the previous listing and generates a prime-length key for each user key passed. One of 50 prime values (between 1,009 and 1,999) is selected as a function of the key passed. The prime key is then generated using a simple summing-ANDing-exclusive-ORing algorithm, and the file is encrypted using this new key. If two or more keys are used, this method guarantees a cypher period in excess of 1,000,000, which is significantly larger than most text files.

The key-generation scheme is based entirely on the original key length and its contents, and I fail to see how this can be worked backward to regain the original, especially if multiple keys are used. Some keys will generate shorter periods within the prime length, but this is easily tested with the tools provided. I welcome feedback or suggestions for improving this algorithm.

#### Cypher3.c—Listing Four

Adding chaos to disorder has probably driven many a code cracker to drink, and this is just what I'm trying to accomplish. I have modified the cypher2.c algorithm slightly to test the first character of each key passed. If the key begins with a dash (-), then the buffer is transposed by some value between 2 and 17; otherwise, it encrypts the file using the algorithm as described above. This simple but effective method puts the

```
f-1
       0000
                       2A
                            09
                                 63
                                     79
                                          70
                                               68
                                                    65
                                                         72
                                                              31
                                                                   2E
                                                                       63
                                                                            09
                                                                                 43
                                                                                      79
                                                                                           70
                                                                                                     /*cypher1.c Cyp
f-1
      0010
                  68
                       65
                            72
                                 20
                                     6D
                                          6F
                                               64
                                                    75
                                                         6C
                                                              65
                                                                   09
                                                                       09
                                                                            62
                                                                                 79
                                                                                      20
                                                                                           46
                                                                                                     her module by F
f-1
      0020
                  2E
                       41
                            2E
                                 53
                                     63
                                          61
                                               63
                                                                   74
                                                    63
                                                         68
                                                              69
                                                                       74
                                                                            69
                                                                                 0D
                                                                                      OA
                                                                                           2A
                                                                                                     .A.Scacchitti
f-1
      0030
                  2A
                       09
                            09
                                09
                                     09
                                          09
                                               09
                                                         31
                                                                   2F
                                                    09
                                                              30
                                                                       31
                                                                            30
                                                                                 2F
                                                                                      38
                                                                                           35
                                                                                                              10/10/85
                                                                                                     ^^**^^**^Simple
f-1
      0040
                  0D
                       OA
                            2A
                                2A
                                     0D
                                          OA
                                               2A
                                                    2A
                                                         09
                                                              53
                                                                   69
                                                                            70
                                                                                 6C
                                                                                      65
                                                                                           20
f-1
      0050
                                               20
                  63
                       79
                            70
                                68
                                     65
                                          72
                                                    6D
                                                         6F
                                                              64
                                                                   75
                                                                       6C
                                                                            65
                                                                                 20
                                                                                      2D
                                                                                           20
                                                                                                     cypher module -
f-1
                  65
      0060
                       6F
                            63
                                6F
                                     64
                                          65
                                               73
                                                    20
                                                         64
                                                              69
                                                                   72
                                                                       65
                                                                            63
                                                                                 74
                                                                                      6C
                                                                                           79
                                                                                                     encodes directly
f-1
      0070
                       77
                  20
                            69
                                74
                                     68
                                          20
                                               75
                                                    73
                                                         65
                                                              72
                                                                   20
                                                                       6B
                                                                            65
                                                                                 79
                                                                                      73
                                                                                           OD
                                                                                                      with user keys
f-1
      0080
                  OA
                       2A
                           2A
                                0D
                                                    0D
                                                                                                     *****
                                     OA
                                          2A
                                               2F
                                                         OA
                                                              OD
                                                                  OA
                                                                       23
                                                                            69
                                                                                 6E
                                                                                      63
                                                                                           6C
                                                                                                                 #incl
f-1
      0090
                  75
                       64
                            65
                                20
                                     3C
                                          73
                                               74
                                                    64
                                                         69
                                                              6F
                                                                   2E
                                                                       68
                                                                            3E
                                                                                 OD
                                                                                      OA
                                                                                           0D
                                                                                                     ude <stdio.h>
f-1
      00A0
                       73
                  OA
                            74
                                61
                                     74
                                          69
                                               63
                                                    20
                                                         69
                                                              6E
                                                                  74
                                                                       20
                                                                                 2C
                                                                            69
                                                                                      20
                                                                                           6E
                                                                                                      static int i, n
f-1
      00B0
                  2C
                      20
                           6B
                                65
                                     79
                                          6C
                                               65
                                                    6E
                                                         67
                                                              74
                                                                   68
                                                                       3B
                                                                            0D
                                                                                 OA
                                                                                      OD
                                                                                           OA
                                                                                                     , keylength;
f-1
      00C0
                       79
                  63
                           70
                                68
                                     65
                                          72
                                               31
                                                    28
                                                         62
                                                              75
                                                                  66
                                                                       66
                                                                            65
                                                                                 72
                                                                                      2C
                                                                                           20
                                                                                                     cypher1(buffer,
f-1
      0000
                  6F
                      75
                           60
                                2C
                                     20
                                          63
                                               6F
                                                    64
                                                         65
                                                              29
                                                                  20
                                                                       63
                                                                            68
                                                                                 61
                                                                                      72
                                                                                           20
                                                                                                     num, code) char
f-1
      00E0
                      62
                                          65
                  2A
                           75
                                66
                                     66
                                               72
                                                    2C
                                                         20
                                                              2A
                                                                  63
                                                                       6F
                                                                            64
                                                                                 65
                                                                                      3B
                                                                                           20
                                                                                                     *buffer, *code;
f-1
      00F0
                  69
                       6E
                           74
                                20
                                     6F
                                          75
                                               60
                                                    3B
                                                         7B
                                                             OD
                                                                  OA
                                                                       0D
                                                                            OA
                                                                                 2F
                                                                                      2A
                                                                                           OD
                                                                                                     int num;{
f-1
      0100
                  OA
                      2A
                           2A
                                20
                                     67
                                          65
                                               74
                                                    20
                                                         6B
                                                              65
                                                                  79
                                                                       6C
                                                                            65
                                                                                 6E
                                                                                      67
                                                                                           74
                                                                                                      ** get keylengt
f-1
      0110
                  68
                       20
                           66
                                6F
                                     72
                                          20
                                               65
                                                    61
                                                         63
                                                                       6B
                                                              68
                                                                  20
                                                                            65
                                                                                 79
                                                                                      0D
                                                                                           OA
                                                                                                     h for each key
f-1
      0120
                  2A
                      2F
                           0D
                                OA
                                     0D
                                          OA
                                               20
                                                    20
                                                         20
                                                              6B
                                                                  65
                                                                       79
                                                                            6C
                                                                                 65
                                                                                      6E
                                                                                                     */^^^ keyleng
                                                                                           67
f-1
      0130
                  74
                       68
                           20
                                3D
                                     20
                                          30
                                               3B
                                                    0D
                                                         OA
                                                              20
                                                                  20
                                                                       20
                                                                            77
                                                                                 68
                                                                                      69
                                                                                           6C
                                                                                                     th = 0; \hat{} whil
f-1
      0140
                  65
                      28
                           63
                                6F
                                     64
                                          65
                                               5B
                                                    6B
                                                         65
                                                              79
                                                                  6C
                                                                       65
                                                                            6F
                                                                                 67
                                                                                      74
                                                                                           68
                                                                                                    e(code[keylength
f-1
      0150
                  2B
                      2B
                           5D
                                20
                                     21
                                          3D
                                               20
                                                    4E
                                                         55
                                                              4C
                                                                  4C
                                                                       29
                                                                            3B
                                                                                 OD
                                                                                      OA
                                                                                           20
                                                                                                     ++]!=NULL);
f-1
      0160
                           6B
                  20
                      20
                                65
                                     79
                                          6C
                                               65
                                                    6E
                                                         67
                                                              74
                                                                  68
                                                                       2D
                                                                            2D
                                                                                 3B
                                                                                      OD
                                                                                           OA
                                                                                                     keylength--;
f-1
      0170
                  OD
                      OA
                           2F
                                2A
                                     0D
                                          OA
                                               2A
                                                    2A
                                                         20
                                                              65
                                                                  6E
                                                                       63
                                                                            72
                                                                                 79
                                                                                      70
                                                                                           74
                                                                                                      /*^** encrypt
f-1
      0180
                  20
                      74
                           68
                                65
                                     20
                                          66
                                               69
                                                    6C
                                                         65
                                                             20
                                                                  77
                                                                       69
                                                                            74
                                                                                 68
                                                                                      20
                                                                                           65
                                                                                                     the file with e
f-1
      0190
                  61
                      63
                           68
                                20
                                     6B
                                          65
                                               79
                                                    0D
                                                        OA
                                                             2A
                                                                  2F
                                                                       0D
                                                                            OA
                                                                                 OD
                                                                                                    ach key */
                                                                                      OA
                                                                                           20
f-1
      01A0
                  20
                      20
                           70
                                72
                                     69
                                          6E
                                               74
                                                    66
                                                        28
                                                             22
                                                                  2D
                                                                       65
                                                                            6E
                                                                                 63
                                                                                      6F
                                                                                           64
                                                                                                     printf("-encod
f-1
      01B0
                  69
                      6F
                           67
                                2F
                                     64
                                          65
                                               63
                                                    6F
                                                        64
                                                             69
                                                                  6E
                                                                       67
                                                                            20
                                                                                 62
                                                                                      75
                                                                                           66
                                                                                                    ing/decoding buf
f-1
      01C0
                  66
                      65
                           72
                                5C
                                     6E
                                          22
                                               29
                                                             OA
                                                    3B
                                                        0D
                                                                  0D
                                                                       OA
                                                                            20
                                                                                 20
                                                                                      20
                                                                                           66
                                                                                                    fer\n");
f-1
      01D0
                  6F
                      72
                           28
                                69
                                     3D
                                          30
                                               3R
                                                    20
                                                        69
                                                             3C
                                                                  30
                                                                       6E
                                                                            75
                                                                                 6D
                                                                                      3B
                                                                                           20
                                                                                                    or(i=0; i <= num;
f-1
      01E0
                 69
                      2B
                           2B
                                29
                                     OD
                                          OA
                                               20
                                                    20
                                                        20
                                                             20
                                                                  20
                                                                       20
                                                                            62
                                                                                 75
                                                                                      66
                                                                                           66
                                                                                                    i++)^{\hat{}} buff
f-1
      01F0
                 65
                      72
                           5B
                                69
                                     5D
                                          20
                                               3D
                                                    20
                                                        62
                                                             75
                                                                  66
                                                                       66
                                                                            65
                                                                                 72
                                                                                      5R
                                                                                           69
                                                                                                    er[i] = buffer[i
f-1
      0200
                 5D
                      20
                           5E
                                20
                                     63
                                                                                                    ] code[i % key
                                          6F
                                               64
                                                    65
                                                        5B
                                                             69
                                                                  20
                                                                       25
                                                                            20
                                                                                 6B
                                                                                      65
                                                                                           79
f-1
      0210
                 6C
                      65
                           6E
                                67
                                     74
                                          68
                                               5D
                                                   3R
                                                        OD
                                                             OA
                                                                  7D
                                                                       0D
                                                                            OA
                                                                                 OD
                                                                                      OA
                                                                                                    length]; 1)
                                                                                           1A
f-1
      0220
                  1A
                      1A
                           1A
                                1A
                                     1A
                                          1A
                                               1A
                                                    1A
                                                        1A
                                                             1A
                                                                  1A
                                                                       1A
                                                                            1A
                                                                                 1A
                                                                                      1A
                                                                                           1A
f-1
      0230
                  1A
                      1A
                           1A
                                1A
                                     1A
                                          1A
                                               1A
                                                    1A
                                                        1A
                                                                  1A
                                                             1A
                                                                       1A
                                                                            1A
                                                                                 1A
                                                                                      1A
                                                                                           1A
f-1
      0240
                 1A
                      1A
                           1A
                                1A
                                     1A
                                          1A
                                               1A
                                                    1A
                                                        1A
                                                             1A
                                                                  1A
                                                                       1A
                                                                            1A
                                                                                 1A
                                                                                      1A
                                                                                           1A
f-1
      0250
                 1A
                      1A
                           1A
                                1A
                                     1A
                                          1A
                                               1A
                                                    1A
                                                        1A
                                                             1A
                                                                  1A
                                                                       1A
                                                                            1A
                                                                                 1A
                                                                                      1A
                                                                                           1A
f-1
      0260
                 1A
                      1A
                           1A
                                1A
                                     1A
                                          1A
                                               1A
                                                    1A
                                                        1A
                                                             1A
                                                                  1A
                                                                       1A
                                                                            1A
                                                                                 1A
                                                                                      1A
                                                                                           1A
f-1
      0270
                      1A
                           1A
                                1A
                                     1A
                                          1A
                                               1A
                                                   1A
                                                        1A
                                                             1A
                                                                  1A
                                                                       1A
                                                                                 1A
```

Table 1

icing on the cake; however it completely reverses the decryption method. If the original run string was

cypher file.txt file.new ABRAHAM -2 LINCOLN -3

then the decryption run string would be

cypher file.new file.doc -3 LINCOLN -2 ABRAHAM

#### Fv.c—Listing Five

As I mentioned earlier, this is my replacement for the CP/M dump utility. It allows the user to pass one or two files in the run string for display.

If one file name is passed in the run string, the output appears much like the CP/M dump.com output with the addition of the ASCII display. If two file names are passed, the output consists of a line from file 1, a line from file 2, and a third line containing the exclusive-ORing of the two files (labeled "dif"). In all cases, nonprintable characters are replaced with a caret ( ^ ) in the ASCII portion and nulls are replaced with an equal sign (=) to readily identify comparisons between two files. The comparative output is purely a byte-for-byte operation, and no attempt is made to realign the file to comparing characters as in a compare utility. The first file length controls display length. Table 1, page 60, shows an example of screen output from the run string  $\langle fv \ cypher1.c \rangle$ , and Table 2, below, shows one from the run string  $\langle fv \ cypher1.c \ cypher2.c \rangle$ .

#### Fstat.c—Listing Six

Descriptive statistics is the name of the game here, and as with any statistical evaluation, you must be brutally honest (at least with yourself) to draw an objective conclusion. The entire file is read, 16K at a time. As you read, the occurrences of each of the 256 tokens are accumulated and you obtain the sum of all bytes as well as the *min* and *max* token occurrences. The sum is divided by the total characters to obtain the mean, the

| 000000000000000000000000000000000000000 |              |          | C POR CONTRACTOR |          | 100000000000000000000000000000000000000 | 100000000000000000000000000000000000000 |          |          | ALL CONTRACTOR OF THE PARTY OF | 00000000000 | ****     | 000000000 |          |          | -        | 00000000 |          |  |
|---|--------------|----------|------------------|----------|---|---|----------|----------|---|-------------|----------|-----------|----------|----------|----------|----------|----------|--|
|   |              |          |                  |          |   |   |          |          |   |             |          |           |          |          |          |          |          |  |
| f-1<br>f-2                              | 0000         | 2F<br>2F | 2A<br>2A         | 09       | 63<br>63                                | 79<br>79                                | 70<br>70 | 68<br>68 | 65<br>65  | 72<br>72    | 31<br>32 | 2E<br>2E  | 63<br>63 | 09       | 43<br>43 | 79<br>79 | 70<br>70 | /*^cypher1.c^Cyp<br>/*^cypher2.c^Cyp   |
| dif                                     | 0000         | 00       | 00               | 00       | 00                                      | 00                                      | 00       | 00       | 00  | 00          | 03       | 00        | 00       | 00       | 00       | 00       | 00       | ===== <sup>-</sup> =====               |
| f-1<br>f-2                              | 0010<br>0010 | 68<br>68 | 65<br>65         | 72<br>72 | 20                                      | 6D<br>6D                                | 6F<br>6F | 64<br>64 | 75<br>75  | 6C<br>6C    | 65<br>65 | 09<br>09  | 09       | 62<br>62 | 79<br>79 | 20       | 46<br>46 | her module ^ by F<br>her module ^ by F |
| dif                                     | 0010         | 00       | 00               | 00       | 00                                      | 00                                      | 00       | 00       | 00  | 00          | 00       | 00        | 00       | 00       | 00       | 00       | 00       | ========                               |
| f-1<br>f-2                              | 0020<br>0020 | 2E<br>2E | 41<br>41         | 2E<br>2E | 53<br>53                                | 63<br>63                                | 61       | 63<br>63 | 63<br>63  | 68<br>68    | 69<br>69 | 74<br>74  | 74<br>74 | 69<br>69 | OD<br>OD | 0A<br>0A | 2A<br>2A | .A.Scacchitti ** .A.Scacchitti **      |
| dif                                     | 0020         | 00       | 00               | 00       | 00                                      | 00                                      | 00       | 00       | 00  | 00          | 00       | 00        | 00       | 00       | 00       | 00       | 00       |  |
| f-1                                     | 0030         | 2A       | 09               | 09       | 09                                      | 09                                      | 09       | 09       | 09  | 31          | 30       | 2F<br>2F  | 31<br>31 | 30<br>31 | 2F<br>2F | 38<br>38 | 35<br>35 | *^^^^10/10/85<br>*^^10/11/85           |
| f-2<br>dif                              | 0030<br>0030 | 2A<br>00 | 09               | 09       | 09                                      | 09                                      | 09       | 09       | 09  | 31<br>00    | 30<br>00 | 00        | 00       | 01       | 00       | 00       | 00       | - 10/11/85                             |
| f-1                                     | 0040         | 0D       | 0A               | 2A       | 2A                                      | 0D                                      | 0A       | 2A       | 2A  | 09          | 53       | 69        | 6D       | 70       | 6C       | 65       | 20       | ^^**^^**^Simple                        |
| f-2<br>dif                              | 0040<br>0040 | 0D<br>00 | 0A<br>00         | 2A<br>00 | 2A<br>00                                | 0D<br>00                                | 0A<br>00 | 2A<br>00 | 2A<br>00  | 09          | 43<br>10 | 6F<br>06  | 6D<br>00 | 70<br>00 | 6C<br>00 | 65<br>00 | 78<br>58 | ======X                                |
| f-1                                     | 0050         | 63       | 79               | 70       | 68                                      | 65                                      | 72       | 20       | 6D  | 6F<br>6D    | 64<br>6F | 75<br>64  | 6C<br>75 | 65<br>6C | 20<br>65 | 2D<br>20 | 20<br>2D | cypher module -                        |
| f-2<br>dif                              | 0050<br>0050 | 20<br>43 | 63<br>1A         | 79<br>09 | 70<br>18                                | 68<br>0D                                | 65<br>17 | 72<br>52 | 20<br>4D  | 02          | 0B       | 11        | 19       | 09       | 45       | 0D       | 0D       | C^^^^RM^^^^E                           |
| f-1                                     | 0060         | 65       | 6E               | 63<br>65 | 6F<br>6E                                | 64<br>65                                | 65<br>72 | 73<br>61 | 20<br>74  | 64<br>65    | 69<br>73 | 72<br>20  | 65<br>61 | 63<br>20 | 74<br>6B | 6C<br>65 | 79<br>79 | encodes directly generates a key       |
| f-2<br>dif                              | 0060<br>0060 | 20<br>45 | 67<br>09         | 06       | 01                                      | 01                                      | 17       | 12       | 54  | 01          | 1A       | 52        | 04       | 43       | 1F       | 09       | 00       | E T R C =                              |
| f-1                                     | 0070         | 20       | 77               | 69       | 74                                      | 68                                      | 20       | 75<br>CD | 73  | 65          | 72       | 20        | 6B       | 65<br>6D | 79<br>65 | 73<br>20 | 0D<br>6C | with user keys of some prime I         |
| f-2<br>dif                              | 0070<br>0070 | 20<br>00 | 6F<br>18         | 66<br>0F | 20<br>54                                | 73<br>1B                                | 6F<br>4F | 6D<br>18 | 65<br>16  | 20<br>45    | 70<br>02 | 72<br>52  | 69<br>02 | 08       | 1C       | 53       | 61       | = ^T^O^ER^^Sa                          |
| f-1                                     | 0080         | 0A       | 2A               | 2A       | 0D                                      | 0A                                      | 2A       | 2F<br>0A | 0D  | 0A<br>2A    | 0D<br>20 | 0A<br>20  | 23       | 69<br>20 | 6E<br>20 | 63<br>20 | 6C<br>20 | ^**^^*/^^^#incl                        |
| f-2<br>dif                              | 0800         | 65<br>6F | 6E<br>44         | 67<br>4D | 74<br>79                                | 68<br>62                                | 0D<br>27 | 25       | 2A<br>27  | 2A<br>20    | 2D       | 2A        | 03       | 49       | 4E       | 43       | 4C       | oDMyb'%' -* INCL                       |
| f-1                                     | 0090         | 75       | 64               | 65       | 20                                      | 3C<br>20                                | 73<br>20 | 74<br>20 | 64<br>20  | 69<br>20    | 6F<br>20 | 2E<br>20  | 68<br>20 | 3E<br>20 | 0D<br>20 | 0A<br>20 | 0D<br>20 | ude <stdio.h></stdio.h>                |
| f-2                                     | 0090         | 20<br>55 | 20               | 20<br>45 | 20                                      | 1C                                      | 53       | 54       | 44  | 49          | 4F       | 0E        | 48       | 1E       | 2D       | 2A       | 2D       | UDE= STDIO H-+-                        |

Table 2

# CRYPTOGRAPHER'S TOOLBOX (continued from page 61)

max becomes the mode, and the range is the difference between min and max. Next, the 256-byte array is copied to a second array and sorted to obtain the median.

With all calculations completed, the numerical values of occurrences are displayed in a  $16 \times 16$  display for evaluation. The statistical characteristics are displayed, and the program pauses to await some keyboard entry to display the histogram. Depressing the space bar prints a scaled horizontal histogram of 16 groups  $(0-15, 16-31, \ldots, 241-256)$ .

The ideal random file (which is

what you want to see) would have the following characteristics:

mean 127.5
mode not critical
range < 20% of the total
bytes divided by 256
median at midpoint of range
reasonably flat

Remember I said "ideal!" A sequential file will display these ideal characteristics as well as a true random file. Also, files that look too good statistically should be just as suspect as those that don't. Table 3, below, is the output produced by this article "as is," and Table 4, page 63, is the output when it's encrypted with the

run string

cypher crypt-tb.art new frederick -1 angelo -2 scacchitti -3

In all fairness, I must state that other, possibly better, statistical methods exist for determining randomness. I opted to use descriptive statistics because they are more easily understood and implemented.

#### Makef.c—Listing Seven

This is a simple enough utility but an absolute necessity if you are to evaluate encryption schemes. A file name of n 256-byte blocks is created, and if a value between 0 and 255 is passed, the file will be filled with this value.

```
0
                 2
                       3
                                               7
                                                     8
                                                           9
                                                                       B
                                                                 A
                                                                            C
                                                                                  D
                                                                                               F
                                                                                         E
     0
           0
                 0
                       0
                             0
                                   0
                                         0
                                               0
                                                     0
                                                           0
                                                               333
                                                                       0
                                                                             0
                                                                                 333
                                                                                         0
                                                                                               0
     0
           0
                 0
                       0
                             0
                                   0
                                         0
                                               0
                                                     0
                                                           0
                                                                30
                                                                       0
                                                                             0
                                                                                  0
                                                                                         0
                                                                                               0
  3249
           1
                 6
                      17
                             0
                                   1
                                         0
                                              15
                                                    39
                                                          39
                                                                0
                                                                       1
                                                                            85
                                                                                  50
                                                                                       162
     9
          17
                35
                            10
                      25
                                   9
                                        16
                                              20
                                                     5
                                                           6
                                                                11
                                                                       1
                                                                            0
                                                                                  3
                                                                                        2
                                                                                              2
     0
           0
                46
                      6
                            42
                                  10
                                        19
                                              13
                                                     8
                                                          13
                                                                68
                                                                       2
                                                                            10
                                                                                  28
                                                                                       25
                                                                                              24
    13
          20
                 0
                            28
                      14
                                  59
                                         3
                                               1
                                                     5
                                                           1
                                                                7
                                                                       1
                                                                            3
                                                                                   0
                                                                                        3
                                                                                               1
     0
           0
               841
                     145
                           464
                                 410
                                     1528
                                             315
                                                   217
                                                         551
                                                               914
                                                                            75
                                                                                 518
                                                                                       337
                                                                                             749
   766
         287
                14
                     683
                           832
                               1141
                                       304
                                              89
                                                   151
                                                          36
                                                               244
                                                                       8
                                                                            0
                                                                                  0
                                                                                        00
     0
           0
                 0
                       0
                             0
                                  0
                                         0
                                               0
                                                    0
                                                          0
                                                                 0
                                                                       0
                                                                            0
                                                                                  0
                                                                                         0
                                                                                               0
     0
           0
                0
                       0
                             0
                                         0
                                               0
                                                     0
                                                          0
                                                                 0
                                                                      0
                                                                            0
                                                                                  0
                                                                                         0
                                                                                               0
     0
           0
                0
                       0
                             0
                                         0
                                               0
                                                     0
                                                           0
                                                                0
                                                                      0
                                                                            0
                                                                                  0
                                                                                        0
                                                                                              0
     0
           0
                0
                       0
                             0
                                  0
                                               0
                                                     0
                                                           0
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                                                                      0
                                                                            0
                                                                                  0
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                                                                                              0
     0
           0
                 0
                       0
                             0
                                   0
                                         0
                                               0
                                                     0
                                                           0
                                                                0
                                                                      0
                                                                            0
                                                                                  0
                                                                                        0
                                                                                              0
     0
           0
                 0
                       0
                             0
                                   0
                                         0
                                                     0
                                                           0
                                                                0
                                                                      0
                                                                            0
                                                                                  0
                                                                                        0
                                                                                              0
     0
           0
                 0
                       0
                             0
                                   0
                                         0
                                               0
                                                     0
                                                           0
                                                                0
                                                                            0
                                                                      0
                                                                                  0
                                                                                        0
                                                                                              0
                 0
                       0
                             0
                                   0
                                         0
                                                                      0
                                                                            0
                                                                                  0
                                                                                        0
                                                                                              0
16640 characters read from file CRYPT-TB.ART
file mean = 8506480/16640
                                mode = 32 (20 hex)
file median = 0 file range = 3250 [ min = 0 max = 3249 ]
scale = 156
  0 to 15 = 666 !!*****
 16 to 31 = 30 !!*
 32 to 47 = 3684 ! **
 48 to 63 = 162 !!* *
 64 to 79 = 327 ||***
 80 to 95 = 146!!*
 112 to 127 = 3789 : | * *
128 to 143 =
                0 !!
144 to 159 =
160 to 175 =
               0 !!
176 to 191 =
               0 !!
192 to 207 =
               011
208 to 223 =
               0 !!
224 to 239 =
               0 !!
240 to 255 =
               011
```

Table 3

If no value (or one that is nonnumeric) is passed, each block contains a sequential count from 0 to 255. A benefit of this program is its ability to clean a disk. The user simply creates a file the size of the remaining disk space and then erases it. This results in all free disk space being set as the user defined.

#### Sp.c-Listing Eight

Along with the *fstat* utility, sp.c confirms or denies (maybe even questions) the statistical data you have received. A brute-force search method is used to find matching character strings in the file. By default, the search starts at the first character and searches the first 128 bytes for a

match of four or more characters. If the match depth exceeds the block size it is searching, the program will return to CP/M after displaying the match data. If not, it will continue in its search. Block size to search, minimum depth of comparison, and starting point in the buffer may optionally be changed in the run string.

Also, if an additional argument is passed (one more than the three mentioned), the software converts the data in the buffer to delta form—that is, element[n] = element[n] - element[n+1] for all data in the buffer. After the conversion is made, the search scheme continues as before. This feature allows you to evaluate the file for some mathematical

sequence.

One drawback to this program as it stands is the limiting factor of the buffer size. No attempt is made to search beyond it. This shouldn't matter for most text files.

## Small-C, CP/M, and Miscellaneous

The function *chkkbd()* enables you to stop display (program) activity if Ctrl-S is depressed. Following this with a Ctrl-C causes a return to CP/M, and any other character will allow the program to continue. This function calls a *bdos()* function, so the user may have to modify this for other operating systems. The *getchx()* function is a nonechoing

```
0
    1
       2
          3
             4
               5
                  6
                     7
                        8
                           9
                                B
                                   C
                                     D
                                        E
                                           F
                             A
 68
       68
               71
                  84
                       72
                          59
                             56
                                  55
                                     61
                                        71
                                           71
    57
         63
            77
                     63
                                66
 67
    59
       66
         72
            72
               57
                  63
                     69
                       60
                          58
                             62
                                66
                                  82
                                     60
                                        72
                                           69
 57
    69
       76
         65
            65
               75
                  70
                     56
                       73
                          84
                             71
                                65
                                  65
                                     65
                                        65
                                           71
                          56
                                74
                                  55
                                     74
                                        49
 76
    55
       69
         55
            50
               71
                  69
                     84
                       71
                             69
                                           82
       79
         52
            68
               72
                  63
                     47
                       65
                          57
                             52
                                68
                                  62
                                     57
                                        53
                                           66
 71
    58
                  62
                                61
                                  71
                                     67
                                        41
                                           73
 61
    70
       54
         62
            60
               45
                     79
                       59
                          59
                             66
                                        66
       60
         78
               50
                  76
                     70
                       58
                          66
                             72
                                56
                                  70
                                     65
                                           63
 78
    70
            65
                       74
                                66
                                     66
                                        73
                                           77
       73
         68
            49
               62
                  68
                     60
                          84
                             70
                                  67
 63
    56
 70
         70
                  67
                     57
                       64
                          62
                             68
                                55
                                  61
                                     60
                                        85
                                           70
    60
       63
            66
               58
                                     70
                                        80
    60
       62
         58
            59
               74
                  72
                     61
                       64
                          65
                             66
                                62
                                  57
                                           75
 64
                                76
                                     63
                                        60
                                           66
 56
    55
       58
         71
            58
               65
                  57
                     74
                       51
                          67
                             61
                                  77
 71
    71
       52
         67
            54
               66
                  66
                     76
                       78
                          61
                             58
                                63
                                  52
                                     58
                                        62
                                           71
               68
                  67
                       75
                          66
                             66
                                57
                                  67
                                     56
                                        71
                                           54
 76
    63
       71
         62
            65
 53
    70
       69
         64
               55
                  69
                     70
                       60
                          61
                             70
                                62
                                  73
                                     68
                                        51
                                           66
            54
 76
    52
       69
          56
            54
               62
                  61
                     83
                       72
                          75
                             52
                                56
                                  74
                                     72
                                        77
                                           66
                                        70
                                           62
                     55
                          68
                             64
                                65
                                  63
                                     59
 63
    61
       64
          62
            69
               58
                  57
                       67
16640 characters read from file NEW
file mean = 12607580/16640 \text{ mode} = 142 \text{ (8E hex)}
file median = 65 file range = 45 [ min = 41 max = 85 ]
scale = 21
```

Table 4

# CRYPTOGRAPHER'S TOOLBOX (continued from page 63)

version of getchar() that uses BDOS function 6. You can substitute getchar() for getchx().

The functions calloc(), malloc(), and cfree() are used for the dynamic allocation and deallocation of memory. My allocation/deallocation scheme is of the simple variety in which the programmer must pay heed to order or pay the consequences. The source code contained here should work with most implementations of these functions.

Printer output can be obtained from any of the programs by using the CP/M Ctrl-P function. It was the simplest method to implement.

Math functions (especially floating point) are difficult for Small-C. There are several routines in the fstat.c source that perform the necessary long and fractional calculations. It's not necessary to change these; however, if your compiler supports floats and longs, have at it.

Each program will display the usage if entered without the proper number of arguments in the run string. Also, because most software users begin to feel uncomfortable when their computer is off somewhere performing exotic calculations, each program displays status to the screen to put these fears at rest.

#### Cypher Benchmarks

My version, written in Small-C, is generic enough to adapt to any C compiler. Running on a 4-MHz, Z80-based CP/M system, it benchmarks at less than 1K per second for file I/O, 16K per second for file transposition, and approximately 4K per second per key for encryption. Key encryption is difficult to benchmark because it includes the time to generate the prime-length key, which varies from 1,009 to 1,999 characters in length.

#### **And Finally**

These tools should be employed with a measure of common sense. A strong cypher is indicated only when both statistically and patternwise indicated. (And it doesn't hurt to view the file either.) My intent in developing these utilities was to provide the cryptographer-programmer with a means to evaluate the strength of an encryption scheme as well as the resistance of schemes to cracking. Like most tools, however, these can be used for destructive as well as constructive purposes. The author assumes no liability for illegal use of these tools and sincerely believes they can result only in the development of stronger encryption schemes.

#### (Listings begin on page 94.)

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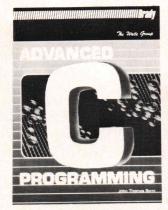
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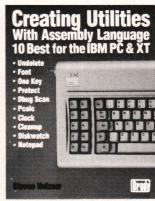
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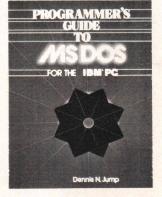
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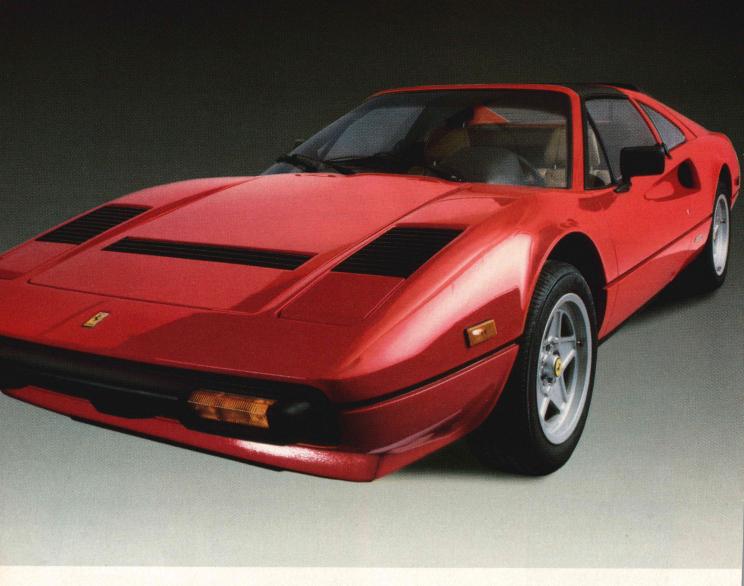
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#### Listing One (Text begins on page 8.)

```
LJ.C -- A printing utility for the HP LaserJet
               This program prints a series of files on the LaserJet printer. The files are printed in a 'landscape!' font 17 characters to the inch. To take advantage of this density, two 'bages!' of information from the file are printed on each piece of paper (left and right halves).
** ** **
               Usage is: LJ file1 file2 file3 ...
               Where file# is a valid MS-DOS filename, included on the command line. This program is compatible with Lattice C on the IBM PC and the HP Touchscreen computers.
               Joe Barnhart original version May 5,
Ray Duncandate and time stamping May 22,
Tevised date stamping
Ray Moon modified for CI86 December 13, 1985
6 revised EOF test
                                                                           May 5, 1985
May 22, 1985
                                                                                           June 6, 1985
**/
#define CI86
                                              /* Remove this #define => Lattice C version */
 #ifdef CI86
 #include <stdio.h>
#else
#include <h\stdio.h>
 #endif
#define MAXLINE 56
#define Page
#define TAB
                                                             /* maximum lines per page */
                                                                            /* for compilers without '/f' */
/* width of one tab stop */
#ifdef CI86
typedef struct {
            unsigned short ax,bx,cx,dx,si,di,ds,es;
) REGSET;
#else
typedef struct {
              int ax, bx, cx, dx, si, di;
} REGSET;
#endif
int filenum;
FILE *fp, *prn, *fopen();
               else {
                              /* initialize the LaserJet for landscape printing */
fprintf(prn, '\'033E\033&11o\033(s17H\033&18d6E'');
for(filenul=1; filenum < argc; filenum++) {
    fp = fopen(argv (filenum), '\r'');
    if (fp = NULL)</pre>
                                                            printf('file %s doesn't exist.\n'', argv [filenum])
                                              else (
                                                             printf('Now printing %s\n'', argv[filenum]);
printfile(fp, prn, argv[filenum]);
fclose(fp);
                              fprintf(prn, ''\015\033E''); /* clear LaserJet */
int pagenum = 1;
while(!feof(fp))
                              fprintf(prn, ''\033&a0r85m5L\015'');
                                                                                               set left half */
                              stamp(prn, filename, pagenum++);
fputc(PAGE, prn);
                                                                                           /* title */
/* kick paper */
printpage(fp,prn)
    FILE *fp, *prn;
               int c, line, col;
              /* newline found */
/* zero column */
                                                            col = 0;
                                                            line++;
fputc('\n',prn);
break;
                                                                                                         /* adv line cnt */
                                             case '\t':
                                                                                          /* TAB found */
                                                            do
                                                            fputc('\040',prn);
while ((++col % TAB) != 0);
                                                                                               (continued on page 70)
```



# PROBLEM: There's just no easy way to move from one software program to another.

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12X

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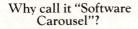
Word Star

1-2-3

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## **LETTERS**

#### Listing One (Listing continued, text begins on page 8.)

```
case PAGE:
                                                                                      /* EOF found */
/* force terminate */
                                           case EOF:
                                                         line = MAXLINE;
                                                         break;
                                                                                      /* no special case */
/* print character */
                                           default:
                                                          fputc(c,prn);
stamp(prn, filename, pagenum)
FILE *prn;
char *filename;
int pagenum;
              char datestr[10], timestr[10];
              fprintf(prn, '\'0334a51171M'');
fprintf(prn, '\'015\0334a58R'');
fprintf(prn, 'File: %-113s'', filename);
fprintf(prn, 'Page %-3d'', pagenum);
                                                                                                     /* widen margins */
                                                                                      /* move to row 58 */
              timestamp(timestr);
datestamp(datestr);
forintf(prn. %
                                               %s'', datestr, timestr);
              fprintf(prn,
REGSET regs;
              int month, day, year;
              regs.ax = 0x2a00;
#ifdef CI86
              sysint21(&regs, &regs);
#else
              int86(0x21,&regs,&regs);
#endif
              month = (regs.dx >> 8) & 255;
              day = regs.dx & 255;

year = regs.cx - 1900;

sprintf(datestr, \%02d/\%02d/\%02d'', month, day, year);
timestamp(timestr)
char *timestr;
              REGSET regs;
              int hours.mins:
              regs.ax = 0x2c00;
#ifdef CI86
              sysint21 (&regs, &regs);
#else
              int86(0x21,&regs,&regs);
#endif
              hours = (regs.cx >> 8) & 255;
mins = regs.cx & 255;
sprintf(timestr, ''%02d:%02d'', hours, mins);
}
```

**End Listing** 

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And Cubit works just as well with floppies and tape cassettes as it does with hard disk drives.

take less time, as well as less space. And communicating compressed files means

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#### C CHEST

#### Listing One (Text begins on page 18.)

```
#include <stdio.h>
   #include <dos.h
   #define NUMROWS
   #define NUMCOLS
   #define VIDBASE
                                 0xb0000000
                                              /* Base address of video screen
                                                 * in canonical form.
   #define NORMAL
                                 0x07
                                          /* Basic Attributes. Only one
   #define UNDERLINED
                                 0x01
                                           /* of these may be present.
12
   #define REVERSE
                                 0x70
14 #define BLINKING
                                 0x80
                                           /* May be ORed with the above
15
   #define BOLD
                                 0x08
                                           /* and with each other
16
17
18
19 typedef struct
20
21
             char
                       letter:
22
                       attribute;
             char
23
24 CHARACTER:
25
26 typedef CHARACTER
                                DISPLAY[ NUMROWS ][ NUMCOLS ];
28 static DISPLAY far *Screen = (DISPLAY far *) VIDBASE;
31
32
   static int
                       Row = 0:
                       Col = 0;
33
   static int
35
36
37
   static void
                       fix cur()
                       Direct video writes won't actually move the cursor so we'll do that with a ROM-BIOS call. move_cur puts the cursor at Row, Col.
39
40
41
42
43
             union REGS
44
                                 Regs;
45
46
              Regs.h.dh = Row;
47
              Regs.h.dl = Col;
48
             Regs.h.bh = 0;
Regs.h.ah = 2;
                                                 /* Use "active" video page
                                                 /* Function 2, set cursor position
49
50
              int86( 0x10, &Regs, &Regs); /* Video int
51 }
52
53
54
55
   void
             setcur ( row, col )
56
57
              Row = row;
58
             Col = col;
59
             fix cur();
60
61
62
63
   void
             getcur( rowp, colp )
*rowp, *colp;
65
   int
66
             *rowp = Row;
*colp = Col;
67
68
69 }
70
71
73
   void
             d_putc( c, attrib )
74
75
             switch(c)
76
77
             case '\r':
                                 Col = 0;
78
                                 break:
79
80
             case '\n':
                                 if ( ++Row >= NUMROWS )
81
                                          Row = 0:
                                break:
83
84
             case '\b':
                                 if( --Col < 0 )
85
                                          Col = 0;
86
87
                                 break;
             default:
88
                                (*Screen)[ Row ][ Col ].letter = c ;
(*Screen)[ Row ][ Col ].attribute = attrib ;
if( ++Col >= NUMCOLS )
89
90
91
92
                                          Col = 0:
```

```
if ( ++Row >= NUMROWS )
 94
95
                                                   Row = 0;
                                 break;
 96
 98
 99
              fix_cur();
100 H
101
102
103
                  d_puts( str, attrib )
104 void
                       *str;
105 register char
    register int
                       attrib;
107 {
              while ( *str )
108
109
                       d putc( *str++, attrib );
110
111
112
113
114
    void
                   clrs ( attrib )
115
                       Clears the screen. The cursor is not moved.
116
117
118
119
              CHARACTER far
                                 *p = (CHARACTER *) VIDBASE ;
                                i ;
120
              register int
121
              for ( i = NUMROWS * NUMCOLS; --i >= 0; )
123
                        (p )->letter
124
125
                        (p++) ->attribute = attrib;
126
127 }
128
129
130
131 main()
132 {
133
              clrs ( NORMAL );
134
              setcur( 0, 0 );
135
              d_puts("Normal\n\r",
d_puts("Normal blinking\n\r",
d_puts("Reverse\n\r",
                                                             NORMAL
136
                                                             NORMAL | BLINKING
137
                                                              REVERSE
138
              d_puts("Underlined\n\r",
d_puts("Underlined bold\n\r",
                                                              UNDERLINED
139
                                                                                          );
                                                              UNDERT, THED I BOLD
140
              d puts ("Underlined blinking bold\n\r",
                                                             UNDERLINED | BOLD | BLINKING);
141
142
               exit (0);
144 }
```

**End Listing One** 

#### Listing Two

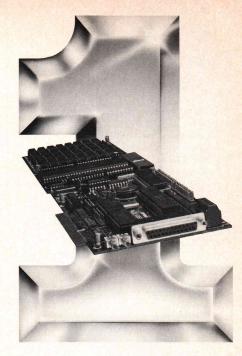
```
main()
{
    /* Exit status == 0 if SHLEV environment exists, else
    * exit status == 1
    */
    exit( getenv("SHLEV") == 0 );
}
```

**End Listing Two** 

#### LISTING THREE

```
# shlev
if($status) then
setenv SHLEV 1
else
setenv SHLEV "'expr $SHLEV + 1'"
endif
# set prompt="[$SHLEV,!] "
```

**End Listings** 



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#### EGA

#### Listing One (Text begins on page 42.)

```
SINE.C
      Plot \sin(x) vs. x on an enhanced color display with an IBM enhanced graphics adapter in the high resolution mode. Purpose is to test the video routines.
       by Nabajyoti Barkakati, Silver Spring, MD 20904.
#include <stdio.h>
#include <math.h>
                                                                           /* Color number 1 is BLUE

/* Color number 4 is RED

/* Bottom margin

/* Top margin

/* Left margin

/* Right margin

/* Approximate value of 2 Pi

/* Points on the sinusoid
#define BLUE
#define RED
#define BOTTOM 4
#define TOP 345
#define LEFT 4
#define RIGHT 635
#define TWOPI 6.283
#define MAXPNT 100
                                                                           /* Approximate value of 2
/* Points on the sinusoid
       int i, x, y, oldx, oldy, midpoint;
double xd, yd, ampl;
       v_init (RED);
                                                                           /* Initialize the display
       midpoint = (TOP - BOTTOM)/2;
ampl = (double)midpoint - (double)BOTTOM;
       oldx = LEFT;
       oldy = midpoint;
       for (i=0; i<=MAXPNT; i++)
               yd = ampl * sin(TWOPI * ((double)i)/((double)MAXPNT));
xd = ((double)RIGHT - (double)LEFT)* (double)i / (double)MAXPNT;
x = LEFT + (int)xd;
y = midpoint + (int)yd;
/* Draw a line from the old point to the new point */
               v_draw (oldx, oldy, x, y, BLUE);
/* Save the new coordinates */
               oldy = y;
/* Draw a box around the plot */
      v_draw (LEFT, BOTTOM, RIGHT, BOTTOM, BLUE);
v_draw (RIGHT, BOTTOM, RIGHT, TOP, BLUE);
v_draw (RIGHT, TOP, LEFT, TOP, BLUE);
v_draw (LEFT, TOP, LEFT, BOTTOM, BLUE);
/* Done */
```

**End Listing One** 

#### Listing Two

```
VIDEO C
      This file contains the video display modules. Uses the int86 function of Lattice C 2.14 to draw graphs on an enhanced color display with the IBM enhanced graphics adapter.
      by N. Barkakati, Silver Spring, MD 20904.
#include <dos.h>
#define void
#define EGAMODE
                                                                     /* EGA in high resolution
#define MAXROW
                                 24
#define MAXCOL
#define MAXYDOT
#define MAXXDOT
                                                                     /* Max. columns and rows on
/* enhanced color display
#define BIOS_VIDEO 16
#define SETMODE 0
#define SETCOLOR 11
                                                                     /* BIOS Video service int. no. */
/* Service: set video mode */
                                                                     /* Service: set video mode */
/* Service: set color pallette */
/* Service: write pixel */
#define WRITE_PIX 12
static union REGS xr,yr;
                                                                     /* See dos.h for explanation
    v_init
      Initialize the display. Put it in EGA hi-resolution mode. Set background color.
```

```
void v init (bgcolor)
int bgcolor;
/* ROM BIOS Video functions -- mode 16 is EGA in high-resolution
      (640x350 pixels)
       xr.h.ah = SETMODE;
xr.h.al = EGAMODE;
int86 (BIOS_VIDEO, &xr, &yr);
     Set color.
       xr.h.ah = SETCOLOR;
xr.h.bh = 0;
xr.h.bl = bgcolor;
int86 (BIOS_VIDEO, &xr, &yr);
      v_draw
       Draw a line of specified color between the two points (x1,y1) and (x2,y2). Uses Bresenham's Algorithm described in: J.D. Foley and A. Van Dam, FUNDAMENTALS OF INTERACTIVE COMPUTER GRAPHICS, Addison-Wesley, 1982, pp.433-435.
 void v_draw(x1, y1, x2, y2, color)
int x1, y1, x2, y2, color;
        int dx, dy, incr1, incr2, incr3, d, x, y, xend, yend; dx = abs(x2-x1); dy = abs(y2-y1); if (dy<-dx) /* Absolute value of close of line is
                                  /* Absolute value of slope of line is less than 1 */
               if (x1>x2)
                                             /* Start at point with smaller x coordinate */
                     x = x2;
y = y2;
xend = x1;
                      dy = y1-y2;
                else
                      x = x1;
y = y1;
xend = x2;
                      dy = y2-y1;
               d = 2*dy-dx;
incr1 = 2*dy;
incr2 = 2*(dy-dx);
incr3 = 2*(dy+dx);
                putdot (x, y, color);
while (x < xend)</pre>
                      x += 1;
if (d >= 0)
                              if (dy<=0)
                                                                           /* Negative or zero slope */
                                                                                        /* Positive slope */
                                     y += 1;
d += incr2;
                        else
                              if (dy >= 0)
                                                                           /* Negative or zero slope */
                                     d += incr1;
                               else
                                                                                         /* Positive slope */
                              y -= 1;
d += incr3;
                        putdot (x, y, color);
                                                                                                  /* end while */
/* end if */
                                           /* Absolute value of slope is greater than 1 */
           else
                 if (y1>y2)
                                           /* Start with point with samller y coordinate */
                        yend = y1;
dx = x1-x2;
                  else
                        y = y1;
x = x1;
yend = y2;
                 }
d = 2*dx-dy;
incr1 = 2*dx;
incr2 = 2*(dx-dy);
incr3 = 2*(dx+dy);
putdot (x, y, color);
while (y < yend)</pre>
```

(continued on page 77)



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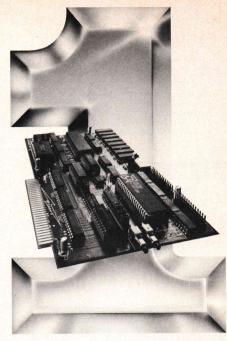
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#### Listing TWO (Listing continued, text begins on page 42.)

```
y += 1;
if(d >= 0)
                     if (dx <= 0)
                                                          /* Negative or zero slope */
                           d += incr1;
                      else
                                                                      /* Positive slope */
                           x += 1;
d += incr2;
                      if (dx >= 0)
                                                          /* Negative or zero slope */
                           d += incr1;
                                                                      /* Positive slope */
                           x -= 1;
d += incr3;
                putdot (x, y, color);
                                                                             /* end while */
/* end else */
/* Done */
    putdot
     Put a dot of specified color at location (x,y) on screen. Check if dot coordinates are within screen bounds.
                         ~ v-axis
                                          Origin at lower left corner of screen.
    Convention:
               (0,0)->1
                                     x axis
void putdot(x, y, color)
int x, y, color;
     if ( x<0 | x>MAXXDOT | y<0 | y>MAXYDOT ) return;
     xr.x.dx = MAXYDOT - y;
xr.x.cx = x;
xr.h.ah = WRITE_PIX;
xr.h.al = color;
int86 (BIOS_VIDEO, &xr, &yr);
```

**End Listings** 



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|------------|
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#### **68K ASSEMBLER**

#### Listing Eleven (Text begins on page 44.)

```
IMPLEMENTATION MODULE LongNumbers;
(* Routines to handle HEX digits for the X68000 cross assembler. *)
(* All but LongPut and LongWrite are limited to 8 digit numbers. *)
      FROM Files IMPORT FILE;
      IMPORT Files; (* Write *)
      IMPORT Terminal; (* Write *)
(* These objects are declared in the DEFINITION MODULE *)
           DIGITS = 8;
BASE = 16;
           LONG = ARRAY [1..DIGITS] OF INTEGER:
      CONST
           Zero = 30H;
Nine = 39H;
hexA = 41H;
hexF = 46H;
      PROCEDURE LongClear (VAR A : LONG);
(* Sets A to Zero *)
          VAR
i : CARDINAL;
          BEGIN
FOR i := 1 TO DIGITS DO
A[i] := 0;
END;
END LongClear;
      PROCEDURE LongAdd (A, B : LONG; VAR Result : LONG); (* Add two LONGs, giving Result *)
                 Carry : INTEGER;
i : CARDINAL;
                 SIN

Carry := 0;

FOR i := 1 TO DIGITS DO

Result[i] := (A[i] + Carry) + B[i];

IF Result[i] >= BASE TIEN

Result[i] := Result[i] - BASE;

Carry := 1;

ELSE
                      Carry := 0;
END;
           END;
END LongAdd;
      PROCEDURE LongSub (A, B : LONG; VAR Result : LONG); (* Subtract two LONGs (A - B), giving Result *)
                 Borrow : INTEGER;
i : CARDINAL;
                 SIN
Borrow := 0;
FOR i := 1 TO DIGITS DO
Result[i] := (A[i] - Borrow) - B[i];
IF Result[i] <- O TENN
Result[i] := Result[i] + BASE;
Borrow := 1;
ELSE
Borrow := 0;
END;
END;</pre>
           END;
END LongSub;
      PROCEDURE CardToLong (n : CARDINAL; VAR A : LONG); (* Converts CARDINALs to LONGs *)
           VAR
i : CARDINAL;
                 LongClear (A);
                 1 := 1
```

#### **End Listing Eleven**

#### Listing Twelve

```
BEGIN

IF ORD (CommandLine[0]) = 0 THEN
ArgC := 0; (* Nothing in Command Tail Buffer *)
ArgV := NIL;
ELSE
i := 1; C := 0;

LOOP

WHILE CommandLine[i] = ' ' DO (* Skip Blanks *)
INC (1);
END;

IF CommandLine[i] = 0C THEN (* end of tail buffer *)
EXIT;
ELSE
Aguments[C] := ADR (CommandLine[i]);
INC (0);
IF C ** MAXARGS THEN
EXIT;
END;
END;

WHILE CommandLine[i] # ' ' DO (* Advance to next Argument *)
INC (1);
IF CommandLine[i] = 0C THEN
EXIT;
END;
END;

CommandLine[i] := 0C; (* Terminate Argument *)
INC (1);
END; (* LOOP *)

CommandLine[0] := 0C; (* Command Tail must only be used once *)
ArgC := C;
ArgV := ADR (Arguments);
END CmdLin2.
```

#### **End Listing Twelve**

#### Listing Thirteen

```
IMPLEMENTATION MODULE Parser;
(* Reads the Source file, and splits each *)
(* line into Label, OpCode & Operand(s). *)
    FROM Strings IMPORT
    FROM Files IMPORT
FILE, EOF, Read;
    FROM ErrorX68 IMPORT
ErrorType, Error;
(* These objects are declared in the DEFINITION MODULE *)
         TOKEN = ARRAY [0..TokenSize] OF CHAR;
OPERAND = ARRAY [0..OperandSize] OF CHAR;
         Oploc, SrcLoc, DestLoc : CARDINAL; (* location of line parts *)
Line : STRINC;
LineCount : CARDINAL;
    PROCEDURE GetLine (f : FILE; VAR EndFile : BCOLEAN);
(* Inputs a Line -- up to 80 characters ending in cr/lf -- from a file. *)
         CONST
             MAXLINE = 80;
        VAR
i : CARDINAL;
ch : CHAR;
         PROCEDURE Get (VAR c : CHAR) : CHAR;
              BEGIN

IF NOT EOF (f) THEN

Read (f, c);

RETURN c;

ELSE
                        EndFile := TRUE;
                  END:
             END Get:
             i := 0;
WHILE (i < MAXLINE) AND (Get (ch) # ASCII.1f) AND (NOT EndFile) DO
Line[i] := ch;
INC (i);
END;
             IF Line[i - 1] = ASCII.cr THEN (* Strip cr/lf - terminate with 0C *)
Line[i - 1] := 0C;
             Line[i] := 0C;
END;
         INC (LineCount);
END GetLine;
   PROCEDURE SplitLine (VAR Label, Opcode : TOKEN;
VAR SrcOp, DestOp : OPERAND);
(* Separates TOKENS & OPERANDS from Line. *)
```

(continued on page 82)

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#### **68K ASSEMBLER**

#### Listing Thirteen

(Listing continued, text begins on page 44.)

```
Quote = 47C;
StringMAX = 12;
VAR
     i, j : CARDINAL;
ParCnt : INTEGER;
c : CHAR;
InQuotes : BOOLEAN;
                                          (* Tracks open parentheses *)
PROCEDURE Cap (ch : CHAR) : CHAR;
     DEGIN

IF InQuotes THEN
RETURN (ch);
ELSE
RETURN CAP (ch);
     END;
END Cap;
PROCEDURE White (ch : CHAR) : BOOLEAN;
      RETURN ((ch = ASCII.ht) OR (ch = ' '));
END White;
PROCEDURE Delimiter (ch : CHAR) : BOOLEAN;
      PROCEDURE OpDelimiter (ch : CHAR) : BOOLEAN;
      RETURN ((NOT InQuotes) AND (ch = ',') AND (ParCnt = 0));
END OpDelimiter;
PROCEDURE Done (ch : CHAR) : BOOLEAN;
(* look for start of comment or NULL terminator *)
BEGIN
            RETURN ((ch = ';') OR (ch = 0C) OR ((ch = '*') AND (i = 0)));
BEGIN (* SplitLine *)
i := 0;
InQuotes := FALSE;
      IF Done (Line[i]) THEN (* look for blank or all-comment line *)
   RETURN;
      IF White (Line[i]) THEN
INC (i);
INC (1);

WHILE White (Line[i]) DO

INC (1); (* Skip spaces & tabs *)

END;

END;

j:=0;

c:= Line[i];

WHILE (NOT Delimiter (c)) AND (j < TokenSize) DO

Label[j]:= CAP (c);

INC (i); INC (j);

c:= Line[i];

END;
      END;

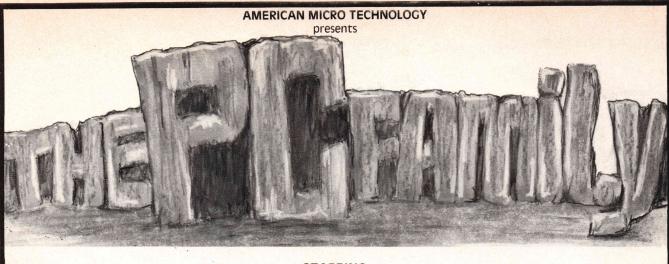
Label[j] := OC; (* te

IF j = TokenSize THEN

Error (i, TooLong);
                                          (* terminate Label string *)
      LND;
WHILE NOT Delimiter (Line[i]) DO
INC (i); (* Skip remainder of Too-Long Token *)
END;
WHILE White (Line[i]) DO INC (i); END;
IF Done (Line(i)) THEN
RETURN;
ELSE (* Found an OpCode *)
OpLoc := i;
j := 0;
c := Line[i];
WHILE (NOT Delimiter (c)) AND (j < TokenSize) DO
OpCode[j] := CAP (c);
INC (i); INC (j);
c := Line[i];
END: Line[i];
      END;
OpCode[j] := OC;
IF j = TokenSize THEN
Error (1, TooLong);
END;
WHILE NOT Delimiter (Line[i]) DO
INC (i); (* Skip remainder of Too-Long Token *)
END;
END;
WHILE White (Line[i]) DO INC (i); END;
IF Done (Line[i]) THEN
       RETURN;
E (* Found 1st Operand *)
     SE (* Found 1st Open...)

Frechoe := ';
    j:=0 := ';
    j:=0;
    c:= Line(1);
    Fr c = Quote THEN (* String Constant *)
    SrcOp[j] := c;
    INC (1); INC (j);
    prppAT
            REPEAT
    c := Line[i];
    SrcOp[j] := c;
    InC (i);    InC (j);
UNTIL (c = Quote) OR (j > StringMAX) OR (c = 0C);
SrcOp[j] := 0C;
If j > StringMAX THEN
    Error (i, TooLong);
FND:
      END;
RETURN; (* second operand not allowed after string constant *)
EISE (* Normal Operand *)
WHILE (NOT Delimiter (c))
AND (NOT Opbelimiter (c))
AND (NOT Opbelimiter (c))
AND () < Operandsize) DO
IF c = Quote THEN
```

(continued on page 84)



STARRING

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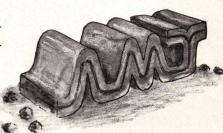
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#### **68K ASSEMBLER**

#### Listing Thirteen (Listing continued, text begins on page 44.)

```
InQuotes := NOT InQuotes; (* Toggle Switch *)
                              END;
IF NOT INQUOTES THEN
IF c = '(' THEN
INC (ParCnt);
                                     IF c = ')' THEN
DEC (ParCnt);
                                     END;
                         END;

END;

STCOp[j] := Cap (c);

INC (i); INC (j);

c := Line[i];

END;

STCOp[j] := OC;

IF j = OperandSize THEN

Error (i, TooLong);
                                                                            (* Switched CAP function *)
                         END:
                  END;
END;
WHILE (NOT Delimiter (Line[i])) AND (NOT OpDelimiter (Line[i])) DO
_____INC (i); (* Skip remainder of Too-long Operand *)
            IF NOT OpDelimiter (Line[i]) THEN RETURN; (* because only one OPERAND *)
ELSE (* Found 2nd Operand *)
INC (i); (* Skip OpDelimiter (comma) *)
DestLoc := i;
                 DestLoc := i;
j := 0;
c := Line[i];
WHILE (NOT Delimiter (c)) AND (j < OperandSize) DO
DestOp[j] := CAP (c);
INC (i); INC (j);
c := Line[i];
END;
DestOp[j] := OC;
IF j = OperandSize THEN
Error (i, TooLong);
END;
D;</pre>
             END
       END SplitLine;
PROCEDURE LineParts (f : FILE; VAR EndFile : BOOLEAN;
VAR Label, OpCode : TOKEN;
VAR SrcOp, DestOp : OPERAND);
(* Reads line, breaks into tokens, on-passes to symbol & code generators *)
             Line := "";
GetLine (f, EndFile); (* read a line from the file *)
             Label := ""; OpCode := ""; SrcOp := ""; DestOp := ""; IF EndFile THEN
                   Error (0, EndErr);
ELSE
             ELSE SplitLine (Label, OpCode, SrcOp, DestOp); END; END LineParts;
BEGIN (* MODULE Initialization *)
Oploc := 0; SrcLoc := 0; DestLoc := 0; LineCount := 0;
END Parser.
```

#### **End Listing Thirteen**

#### **Listing Fourteen**

```
IMPLEMENTATION MODULE SymbolTable;
(* Initializes symbol table. Maintains list of all labels, *)
(* along with their values. Provides access to the list. *)
FROM LongNumbers IMPORT
   LONG, LongClear;
FROM Parser IMPORT
   TOKEN;
FROM Strings IMPORT
   CompareStr;

CONST
   MAXSYM = 500; (* Maximum entries in Symbol Table *)

TYPE
   SYMBOL = RECORD
    Name: TOKEN;
    Value: LONG;
   END;

VAR
   SymTab: ARRAY [1.MAXSYM] OF SYMBOL;
   Next: CARDINAL; (* Array index into next entry in Symbol Table *)
   Top: INTEGER; (* Last used array position as seen by Sort *)

PROCEDURE FillSymTab (Label: TOKEN; Value: LONG; VAR Full: BOOLEAN);
(* Add as symbol to the table *)
   BEGIN
   IF Next < MAXSYM THEN
   SymTab[Next].Value: Value;
   INC (Next);
   Full: FALSE;
   ELSE
   Full: TRUE;
   END;
FIND FillSymTab;

PROCEDURE SortSymTab (VAR NumSyms: CARDINAL);
(* Sort symbols into alphabetical order *)

VAR
   i, gap: INTEGER; (* Shell Sort causes j to go negative *)
   Temp: SYMBOL;</pre>
```

```
DCEUURD omay,
BEGIN
   Temp := SymTab[j];
   SymTab[j] := SymTab[j + gap];
   SymTab[j + gap] := Temp;
END Swap;
                  gap := gap DIV 2;
END;
                         END
            NumSyms := Top;
END SortSymTab;
      PROCEDURE ReadSymTab (LABEL : ARRAY OF CHAR;

VAR Value : LONG; VAR Duplicate : BOOLEAN) : BOOLEAN;

(* Passes Value of Label to calling program — returns FALSE if the *)

(* Label is not defined. Also checks for Multiply Defined Symbols *)
                   GoLower = -1;
GoHigher = +1;
                  R
i, j, mid : INTEGER;
Search : INTEGER;
Found : BOOLEAN;
c : CHAR;
Label : TOKEN;
            BECTN
                  LongClear (Value);
Duplicate := FALSE:
                  1 := 0;

REPEAT

c := LABEL[i];

Label[i] := c;

INC (1);

UNTIL (c = 0C) OR (i > 8);
                  i := 1;
j := Top;
Found := FALSE;
                  REPEAT (* Binary search *)
  mid := (i + j) DIV 2;
  Search := CompareStr (Label, SymTab[mid].Name);
                        IF Search = GoLower THEN
                       if Search = Golower THEN
    j := mid - 1;
ELSIF Search = GoHigher THEN
    i := mid + 1;
ELSE (* Got It! *)
    Found := TRUE;
                 END;
UNTIL (j < i) OR Found;
                 IF Found THEN
    IF mid > 1 THEN
    IF CompareStr (SymTab[mid].Name, SymTab[mid - 1].Name) = 0 THEN
        Duplicate := TRUE; (* Multiply Defined Symbol *)
                              END;
                        END;
END;
IF mid < Top THEN
IF CompareStr (SymTab[mid].Name, SymTab[mid + 1].Name) = 0 THEN
Duplicate := TRUE; (* Multiply Defined Symbol *)
END;
                       Value := SymTab [mid].Value;
RETURN TRUE;
                         RETURN FALSE:
            END;
END ReadSymTab;
     PROCEDURE ListSymTab (i : CARDINAL; VAR Label : TOKEN; VAR Value : LONG);

(* Returns the i-th item in the symbol table *)

BEIN

IF i < Next THEN

Label := SymTab[i].Name;

Value := SymTab[i].Value;
          END;
END ListSymTab;
BEGIN (* MODULE Initialization *)
FOR Next := 1 TO MAXSYM DO
SymTab[Next].Name := "";
LongClear (SymTab[Next].Value);
Top := 0;
Next := 1;
END SymbolTable.
```

**End Listing Fourteen** 

(Listing Fifteen begins on page 86.)

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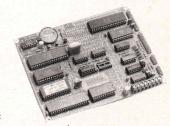
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#### **68K ASSEMBLER**

#### Listing Fifteen (Listing continued, text begins on page 44.)

```
IMPLEMENTATION MODULE OperationCodes;
(* Initializes lockup table for Mnemonic OpCodes. Searches the table *)
(* and returns the bit pattern along with address mode information. *)
              FROM Files IMPORT
FILE, FileState, Open, ReadRec, Close;
              FROM Terminal IMPORT
WriteString, WriteLn;
             FROM Strings IMPORT
STRING, CompareStr;
              FROM Parser IMPORT
TOKEN;
             FROM ErrorX68 IMPORT
ErrorType, Error;
                                                                                                             (* First 68000 OpCode *)
(* Last 68000 OpCode *)
 {*---
(* These objects are declared in the DEFINITION MODULE *)
        TYPE
ModeTypeA = (RegMem3, Ry02, Ry91, Data911, CntR911, Brnch, DecBr, Data03, Opt68, 
                                                                                                                                                               (* 0 = Register, 1 = Memory *)
(* Register Rx -- Bits 0-2 *)
(* Register Ry -- Bits 9-11 *)
(* Immediate Data -- Bits 9-11 *)
(* Count Register or Immediate Data *)
(* Relative Branch *)
(* Decrement and Branch *)
(* Used for VECT only *)
(* MOVEQ *)
(* Address *)
(* Address *)
(* Compare *)
(* XOR *)
(* Sign Extension *)
(* Register/Memory *)
(* Exchange Registers *)
                          ModeTypeB = (Bit811,
Size67,
Size67,
Size1213A,
Size1213A,
Exten,
EA05a,
EA05b,
EA05c,
EA05c,
EA05c,
EA05c,
EA05x,
EA05x,
EA05x,
EA05x,
EA05z,
                                                                                                                                                                (* Exchange Registers *)

(* BIT operations - bits 8/11 as switch *)

(* 00 = Byte, 01 = Word, 10 = Long *)

(* 01 = Byte, 11 = Word, 10 = Long *)

(* 01 = Byte, 11 = Word, 10 = Long *)

(* 11 = Word, 10 = Long *)

(* DCCode extension required *)

(* Effective Address - ALL *)

(* Less 1 *)

(* Less 1 *)

(* Less 1, 11 *)

(* Less 9, 10, 11 *)

(* Less 0, 1, 3, 4, 11 *)

(* Less 0, 1, 3, 4, 11 *)

(* Dual mode - OR/AND *)

(* Dual mode - MOVEM *)

(* Used only by MOVE *)
                              ModeA = SET OF ModeTypeA;
ModeB = SET OF ModeTypeB;
             TYPE
TableRecord = RECORD
Mnemonic : TOKEN;
Op : BITSET;
AddrModeA : ModeA;
AddrModeB : ModeB;
               VAR
Table68X : ARRAY [FIRST..LAST] OF TableRecord;
i : CARDINAL; (* index variable for initializing Table68K *)
f : FILE;
                PROCEDURE Instructions (MnemonSym : TOKEN;
Oploc : CARDINAL; VAR Op : BITSET;
VAR AddrModeA : ModeA; VAR AddrModeB : ModeB);
(* Uses lookup table to find addressing mode & bit pattern of opcode. *)
                                             Top, Bottom, Look : CARDINAL; (* index to Op-code table *)
Found : BOOLEAN;
Search : INTEGER;
                             BEGIN
Bottom := FIRST;
Top := LAST;
Found := FALSE;
                                             REPEAT (* Binary Search *)
Look := (Bottom + Top) DIV 2;
Search := Comparestr (MnemonSym, Table68K[Look].Mnemonic);
                                                          IF Search = GoLower THEN
                                                         Top := Look - 1;

ELSIF Search = GoHigher THEN

Bottom := Look + 1;

ELSE (* Got It! *)

Found := TRUE;
                                             END;
UNTIL (Top < Bottom) OR Found;
                                          IF Found THEN
(* Return the instruction, mode, and address restristictions *)
Op := Table68K[Look].Op;
AddrModeA := Table68K[Look].AddrModeB;
AddrModeB := Table68K[Look].AddrModeB;
                            Error (OpLoc, NoCode);
END;
END Instructions;
BEGIN (* MODULE Initialization *)
IF Open (f, "OPCODE.DAT") # FileOK THEN
WriteString ("Can't Find 'OPCODE.DAT'.");
Writein;
```

```
HALT;
END;
FOR i := FIRST TO LAST DO
ReadRec (f, Table68K[i]);
END;
If Close (f) # FileOK THEN
(* Don't worry about it! *)
END;
END OperationCodes.
```

**End Listing Fifteen** 

#### Listing Sixteen

```
MODULE InitOperationCodes;
(* Module to construct the file containing the Operation Code Data Table *)
             FROM Files IMPORT
FILE, FileState, Create, WriteRec, Close;
             FROM Parser IMPORT
                       FIRST = 1;
LAST = 118;
                                                                                                                         (* 0 = Register, 1 = Memory *)
(* Register Rx -- Bits 0-2 *)
(* Register Ry -- Bits 9-11 *)
(* Immediate Data -- Bits 9-11 *)
(* Count Register or Immediate Data *)
(* Relative Branch *)
(* Decrement and Branch *)
(* Used for VECT only *)
(* Branch & MOVEQ *)
(* Data *)
(* Address *)
(* Address *)
(* Compare *)
(* XCR *)
(* Sign Extension *)
(* Register/Memory *)
(* Register/Memory *)
(* Exchange Registers *)
             TYPE
                      PE
ModeTypeA = (RegMem3,
Ry02,
Rx911,
Data911,
CntR911,
                                                                      CntR911
Brnch,
DecBr,
Data03,
Data07,
OpM68D,
OpM68C,
OpM68C,
OpM68C,
OpM68S,
OpM68S,
OpM68R,
OpM68R,
                                                                                                                         (* Exchange Registers *)

(* BIT operations - bits 8/11 as switch *)

(* 00 = Byte, 01 = Word, 10 = Long *)

(* 01 = Byte, 11 = Word, 10 = Long *)

(* 01 = Byte, 11 = Word, 10 = Long *)

(* 11 = Word, 10 = Long *)

(* OpCode extension required *)

(* Effective Address - ALL *)

(* Less 1 *)

(* Less 1 *)

(* Less 1, 11 *)

(* Less 9, 10, 11 *)

(* Less 1, 9, 10, 11 *)

(* Less 0, 1, 3, 4, 11 *)

(* Dual mode - OR/AND *)

(* Dual mode - MOVEM *)

(* Dual mode - MOVEM *)

(* Used only by MOVE *)
                      ModeTypeB = (Bit811,
Size67,
Size6,
Size1213A,
                                                                        Size1213.
                                                                        Exten,
EA05a,
                                                                        EA05b.
                                                                        EA05c,
EA05d,
                                                                       EA05e,
EA05f,
                       TableRecord = RECORD
                                                                                    CORD
Mnemonic : TOKEN;
Op : BITSET;
AddrModeA : ModeA;
AddrModeB : ModeB;
           VAR
Table68K: ARRAY [FIRST..LAST] OF TableRecord;
i: CARDINAL; (* index variable for initializing Table68K *)
f: FILE; (* "OPCODE.DAT" *)
BEGIN
i := 1;
WITH Table68K[i] DO
Mnemonic := "ABCD";
Op := {15, 14, 8};
Add:ModeA := ModeA{Rx911, RegMem3, Ry02};
Add:ModeB := ModeB{};
END;
          INC (i);
WITH Table68K[i] DO
Mnemonic := "ADD";
Op := {15, 14, 12};
AddrModeA := ModeA(OpM68D);
AddrModeB := ModeB(EA05y);
            END:
          INC (i);
WITH Table68K[i] DO
Mnemonic := "ADDA";
Op := {15, 14, 12};
AddrModeA := ModeA{OpM68A};
AddrModeB := ModeB{EA05a};
          INC (i);
WITH Table68K[i] DO
Mnemonic := "ADDI";
Op := {10, 9};
AddrModeA := ModeA{};
AddrModeB := ModeB{Size67, EA05e, Exten};
```

(continued on page 88)

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#### **68K ASSEMBLER**

#### Listing Sixteen (Listing continued, text begins on page 44.)

```
INC (i);
WITH Table68K[i] DO
Mnemonic := "ADDQ";
Op := {14, 12};
AddrModeA := ModeA(Data911);
AddrModeB := ModeB[Size67, EA05d];
             INC (i);
WITH Table68K[i] DO
Mnemonic := "ADDX";
Op := {15, 14, 12, 8};
AddrModeA := ModeA{RegMem3, Rx911, Ry02};
AddrModeB := ModeB{Size67};
              INC (i);
WIHH Table68K[i] DO
Mnemonic := "AND";
Op := {15, 14};
AddrModeA := ModeA{OpM68D};
AddrModeB := ModeB{EA05x};
               INC (i);
WITH Table68K[i] DO
          Mnemonic := "ANDI";
Op := {9};
AddrModeA := ModeA{};
AddrModeB := ModeB{EA05e, Size67, Exten};
INC (i);
WITH Table68K[i] DO
Mnemonic := "ASL";
Op := {15, 14, 13, 8};
AddrModeA := ModeA{CntR911};
AddrModeB := ModeB{};
INC (i);
WITH Table68K[i] DO
Mnemonic := "ASR";
Op := {15, 14, 13};
AddrModeA := ModeA(CntR911);
AddrModeB := ModeB();
END;
 INC (i);
WITH Table68K[i] DO
Mnemonic := "BCC";
Op := {14, 13, 10};
AddrModeA := ModeA{Brnch};
AddrModeB := ModeB{};
 INC (i);
WITH Table68K[i] DO
"""BCHG";
           iii Tableb8K[1] DO
Mnemonic := "BCGG";
Op := {6};
AddzModeA := ModeA{};
AddzModeB := ModeB{EA05e, Exten, Bit811};
 INC (i);
WITH Table68K[i] DO
    Mnemonic := "BCLR";
    Op := {7};
Add/modeA := ModeA{};
Add/modeB := ModeB{EA05e, Exten, Bit811};
 INC (i);
WITH Table68K[i] DO
   Mnemonic := "BCS";
Op := {14, 13, 10, 8};
   AddrModeA := ModeA(Brnch);
AddrModeB := ModeB{};
END;
 INC (i);
WITH Table68K[i] DO
Mnemonic := "BEQ";
Op := {14, 13, 10, 9, 8};
AddrModeA := ModeA(Brnch);
AddrModeB := ModeB{};
  WITH Table68K[1] DO
 WITH Table68K[1] DO
Mnemonic := "BGE";
Op := {14, 13, 11, 10};
AddrModeA := ModeA{Brnch};
AddrModeB := ModeB{};
END;
INC (i);
WITH Table68K[i] DO
Mnemonic:= "BGT";
Op := [14, 13, 11, 10, 9];
AddrModeA := ModeA(Brnch);
AddrModeB := ModeB{};
 INC (1);
WITH Table68K[1] DO
Mnemonic := "BBI";
Op := {14, 13, 9};
AddrModeA := ModeA{Brnch};
AddrModeB := ModeB{};
END;
INC (i);
WITH Table68K[i] DO
Mnemonic := "BLE";
Op := {14, 13, 11, 10, 9, 8};
AddrModeA := ModeA{Brnch};
AddrModeB := ModeB{};
INC (i);
WITH Table68K[i] DO
Mnemonic := "BLS";
Op := {14, 13, 9, 8};
AddrModeA := ModeA{Brnch};
AddrModeB := ModeB{};
END;
 INC (i);
WITH Table68K[i] DO
```

```
Mnemonic := "BLT";
Op := {14, 13, 11, 10, 8};
AddrModeA := ModeA{Brnch};
AddrModeB := ModeB{};
INC (i);
WITH Table68K[i] DO
Mnemonic := "BMI";
Op := {14, 13, 11, 9, 8};
Add:ModeA := ModeA{Brnch};
Add:ModeB := ModeB{};
END;
INC (i);
WITH Table68K[i] DO
   Mnemonic: = "ENE";
Op := [14, 13, 10, 9];
AddrNodeA := ModeA{Brnch};
AddrModeB := ModeB{};
 INC (i);
WITH Table68K[i] DO
Mnemonic := "BFL";
Op := {14, 13, 11, 9};
AddrModeA := ModeA{Brnch};
AddrModeB := ModeB{};
INC (i);
WITH Table68K[i] DO
Mnemonic := "BRA";
Op := {14, 13};
AddrModeA := ModeA{Brnch};
AddrModeB := ModeB{};
 INC (i);
WITH Table68K[i] DO
Table := "BSET";
 Mnemonic := "BSTT";
Op := {7, 6};
AddrModeA := ModeA{};
AddrModeB := ModeB{EA05e, Exten, Bit811};
END;
INC (i);
WITH Table68K[i] DO
Mnemonic:= "BSR";
Op := [14, 13, 8];
AddrModeA := ModeA{Brnch};
AddrModeB := ModeB{};
 INC (i);
WITH Table68K[i] DO
Mnemonic := "BTST";
OD := {};
AddrModeA := ModeA{};
AddrModeB := ModeB{EA05c, Exten, Bit811};
END;
 INC (i);
WITH Table68K[i] DO
Mnemonic := "BVC";
Op := {14, 13, 11};
AddrModeA := ModeA{Brnch};
AddrModeB := ModeB{};
 INC (i);
WITH Table68K[i] DO
Mnemonic := "BVS";
Op := {14, 13, 11, 8};
AddrModeA := ModeA{Brnch};
AddrModeB := ModeB{};
 INC (i);
WITH Table68K[i] DO
   Mnemonic := "CBK";
   Op := (14, 8, 7);
   AddrModeA := ModeA{Rx911};
   AddrModeB := ModeB{EA05b};
END;
 INC (i);
WITH Table68K[i] DO
Mnemonic := "CLR";
Op := {14, 9};
AddrModeA := ModeA{};
AddrModeB := ModeA{};
 INC (i);
WITH Table68K[i] DO
Mnemonic := "CMP";
Op := {15, 13, 12};
AddrMode3 := ModeA{OpM68C};
AddrMode8 := ModeA{OpM68C};
END;
INC (i);
WITH Table68K[i] DO
Mnemonic := "CMPA";
Op := {15, 13, 12};
AddrModeA := ModeA{OpM68A};
AddrModeB := ModeB{EA05a};
Mnemonic := "CMPI";

Op := {11, 10};

AddrModeA := ModeA{};

AddrModeB := ModeB{Size67, EA05e, Exten};

END;
INC (i);
WITH Table68K[i] DO
    Mnemonic := "CMPM";
    Op := {15, 13, 12, 8, 3};
    AddrModeA := ModeA{Rx911, Ry02};
AddrModeB := ModeB{Size67};
END;
INC (i);
WITH Table68K[i] DO
    Mnemonic := "DBCC";
Op := {14, 12, 10, 7, 6, 3};
```

```
AddrModeA := ModeA{DecBr};
AddrModeB := ModeB{};
END;
INC (i);
WITH Table68K[i] DO
Mnemonic := "DBCS";
Op := {14, 12, 10, 8, 7, 6, 3};
AddrModeA := ModeA[DecBr};
AddrModeB := ModeB{};
END;
NIC (1);
WITH Table68K[1] DO
Mnemonic := "DBEC";
Op := {14, 12, 10, 9, 8, 7, 6, 3};
AddrModeA := ModeA{DecBr};
AddrModeB := ModeB{};
SND:
  INC (i);
WITH Table68K[i] DO
Mnemonic := "DBF";
Op := {14, 12, 8, 7, 6, 3};
AddrModeA := ModeA{DecBr};
AddrModeB := ModeB{j;
 INC (i);
WITH Table68K[i] DO
Mnemonic := "DBGE";
Op := {14, 12, 11, 10, 7, 6, 3};
AddrModeA := ModeA{DecBr};
AddrModeB := ModeB{};
  INC (i);
WITH Table68K[i] DO
Mnemonic := "DBGT";
   Op := (14, 12, 11, 10, 9, 7, 6, 3);
AddrModeA := ModeA{DecBr};
AddrModeB := ModeS{};
  INC (i);
WITH Table68X[i] DO
    Mnemonic := "DBHI";
    Op := {14, 12, 9, 7, 6, 3};
    AddrModeA := ModeA{DecBr};
    AddrModeB := ModeB{};
END;
  INC (i);
WITH Table68K[i] DO
Mnemonic := "DBLE";
Op := {14, 12, 11, 10, 9, 8, 7, 6, 3};
Add:ModeA := ModeA[DecBr};
Add:ModeB := ModeB{};
INC (i);
WITH Table68X[i] DO
Mnemonic:= "DBLS";
Op:= {14, 12, 9, 8, 7, 6, 3};
Add:ModeA := ModeA{DecBr};
Add:ModeB := ModeB{};
  INC (i);
WITH Table68K[i] DO
Mnemonic := "DBLT";
Op := (14, 12, 11, 10, 8, 7, 6, 3);
AddrModeA := ModeA(DecBr);
AddrModeB := ModeB{};
  INC (i);
WITH Table68K[i] DO
Mnemonic := "DBMI";
Op := {14, 12, 11, 9, 8, 7, 6, 3};
AddrMode := ModeA[DecBr];
AddrModeB := ModeB{};
  INC (i);
WITH Table68K[i] DO
Mnemonic := "DBME";
Op := {14, 12, 10, 9, 7, 6, 3};
AddrModeA := ModeA{DecBr};
AddrModeB := ModeB{};
  INC (i);
WITH Tabole68K[i] DO
Mnemonic := "DBPL";
Op := {14, 12, 11, 9, 7, 6, 3};
Add:ModeA := ModeA(DecBr);
Add:ModeB := ModeB{};
 INC (i);
WITE Table68K[i] DO
Mnemonic := "DBRA";
Op := {14, 12, 8, 7, 6, 3};
AddrModeA := ModeA{DecBr};
AddrModeB := ModeB{};
END;
 INC (i);
WITH Table68K[i] DO
Mnemonic := "DBT";
Op := {14, 12, 7, 6, 3};
AddrModeA := ModeA{DecBr};
AddrModeB := ModeB{};
INC (i);
WITH Table68K[i] DO
    Mnemonic := "DBVC";
    Op := {14, 12, 11, 7, 6, 3};
    AddrModeA := ModeA[DecBr];
    AddrModeB := ModeB{};
END;
 INC (i);
WITH Table68K[i] DO
    Mnemonic := "DBVS";
                                                                     (continued on page 90)
```



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#### **68K ASSEMBLER**

#### Listing Sixteen (Listing continued, text begins on page 44.)

```
Op := {14, 12, 11, 8, 7, 6, 3};
AddrModeA := ModeA{DecBr};
AddrModeB := ModeB{};
END;
 INC (i);
WITH Table68K[i] DO
    Mnemonic := "DIVS";
    Op := {15, 8, 7, 6;;
    AddrModeA := ModeA(Rx911);
    AddrModeB := ModeB(EA05b);
INC (i);
WITH Table68K[i] DO
   Mnemonic := "DIVU";
   Op := [15, 7, 6];
   AddrModeA := ModeA{Rx911};
   AddrModeB := ModeB{EA05b};
END;
 INC (i);
WITH Table68K[i] DO
Mnemonic := "ECR";
Op := {15, 13, 12};
AddrModeA := ModeA{OpM68X};
AddrModeB := ModeB{EA05e};
INC (i);
WITH Table68K[i] DO
Mnemonic := "ECRI";
Op := {11, 9};
AddrModeA := ModeB{5!ze67, EA05e, Exten};
INC (i);
WITE Table68K[i] DO
Mnemonic := "EXC";
Op := {15, 14, 8};
AddrModeA := ModeA{OpM37};
AddrModeB := ModeB{};
 END:
INC (1);
WITH Table68K[1] DO
Table := "EXT";
           M lablebok[] DO
Mnemonic := "EXT";
Op := {14, 11};
AddrModeA := ModeA{OpM68S};
AddrModeB := ModeB{};
INC (i);
WITH Table68K[i] DO
Mnemonic := "ILLEGAL";
Op := [14, 11, 9, 7, 6, 5, 4, 3, 2];
AddrModeA := ModeA[];
AddrModeB := ModeB[];
END;
 INC (i);
WITH Table68K[i] DO
Mnemonic := "JMP";
Op := {14, 11, 10, 9, 7, 6};
AddrModeA := ModeA{};
AddrModeB := ModeB{EA05f};
 INC (i);
WITH Table68K[i] DO
Mnemonic:= "LEA";
Op := (14, 8, 7, 6);
AddrModeA := ModeA{xx911};
AddrModeB := ModeB{EA05f};
END;
INC (1);
WITH Table68K[i] DO
Mnemonic := "LINK";
Op := [14, 11, 10, 9, 6, 4];
AddrModeA := ModeA[Ry02];
AddrModeB := ModeB[Exten];
 INC (i);
WITH Table68K[i] DO
Mnemonic := "LSL";
Op := {15, 14, 13, 9, 8, 3};
AddrModeA := ModeA[CntR911];
AddrModeB := ModeB{};
END;
  INC (i);
WITH Table68K[i] DO
Mnemonic := 'LSR';
Op := {15, 14, 13, 9, 3};
AddrModeA := ModeA[CntR911];
AddrModeB := ModeB[];
 INC (i);
WITH Table68K[i] DO
Mnemonic := "MOVE";
Op := {};
AddModeA := ModeA{};
AddModeA := ModeA{};
END;
 INC (i);
WITH Table68K[i] DO
Mnemonic := "MOVEA";
Op := (6);
AddrModeA := ModeA{Rx911};
AddrModeB := ModeB{Size1213, EA05a};
INC (1);
WITH Table68K[1] DO
    Mnemonic := "MOVEM";
Op := {14, 11, 7};
AddrModeA := HodeA{};
```

```
AddrModeB := ModeB{Size6, EA05z, Exten};
END;
 INC (i);
WITH Table68K[i] DO
Mnemonic := "MOVEP";
Op := {3};
AddrModeA := ModeA{OpM68R};
AddrModeB := ModeB{Exten};
 INC (i);
WITH Table68K[i] DO
Mnemonic := "MOVEQ";
Op := {14, 13, 12};
AddrModeA := ModeA{Data07};
AddrModeB := ModeB{};
 INC (1);
WITH Table68K[i] DO
Mnemonic := "MULS";
Op := {15, 14, 8, 7, 6};
AddrModeA := ModeA{Rx911};
AddrModeB := ModeB{EA05b};
INC (i);
WITH Table68K[i] DO
Mnemonic := "MULU";
Op := {15, 14, 7, 6};
AddrModeA := ModeA{Rx311};
AddrModeB := ModeB{EA05b};
INC (i);
WITH Table68K[i] DO
Mnemonic := "NBCD";
Op := {14, 11};
AddrModeA := ModeA{};
AddrModeB := ModeB{EA05e};
 INC (i);
WITH Table68K[i] DO
Mnemonic := "NEG";
Op := {14, 10};
AddrModeA := ModeA{};
AddrModeB := ModeB{Size67, EA05e};
INC (i);
WITH Table68K[i] DO
Mnemonic := "NEGX";
Op := {14};
AddrHodeA := ModeA{};
AddrHodeB := ModeB{Size67, EA05e};
INC (i);
WITH Table68K[i] DO
Mnemonic := "NOP";
Op := {14, 11, 10, 9, 6, 5, 4, 0};
AddrModeA := ModeA{};
AddrModeB := ModeB{};
INC (i);
WITH Table68K[i] DO
Mnemonic := "NOT";
Op := {14, 10, 9};
Add:ModeA := ModeA{};
Add:ModeB := ModeB{Size67, EA05e};
 Mnemonic := "OR";
Op := {15};
AddrModeA := ModeA{OpM68D};
AddrModeB := ModeB{EA05x};
END;
 INC (i);
WITH Table68K[i] DO
Mnemonic := "ORI";
Op := {};
AddrModeA := ModeA{};
AddrModeB := ModeB{Size67, EA05e, Exten};
 INC (i);
WITE Table68K[i] DO
    Mnemonic := "PEA";
    Op := {14, 11, 6};
    AddrModeA := ModeA{};
    AddrModeB := ModeB{EA05f};
END;
INC (1);
WITH Table68K[i] DO
   Mnemonic := "RESET";
   Op := {14, 11, 10, 9, 6, 5, 4};
   AddrModeA := ModeA{};
   AddrModeB := ModeB{};
 INC (i);
WITH Table68K[i] DO
Mnemonic := "ROL";
Op := {15, 14, 13, 10, 9, 8, 4, 3};
AddrModeA := ModeA{CntR911};
AddrModeB := ModeB{};
END;
 INC (i);
WITH Table68K[i] DO
    Mnemonic := "ROR";
    Op := (15, 14, 13, 10, 9, 4, 3);
    AddrModeA := ModeA{CntR911};
    AddrModeB := ModeB{};
 INC (i);
WITH Table68K[i] DO
Mnemonic := "ROXL";
Op := [15, 14, 13, 10, 8, 4];
AddIMOdeA := ModeA[CntR911];
AddIMOdeB := ModeB{};
END;
```

```
INC (i);
WITH Table68K[i] DO
Mnemonic := "ROKR";
Op := (15, 14, 13, 10, 4);
AddrModeA := ModeA(CntR911);
AddrModeB := ModeB{};
 INC (i);
WITH Table68K[i] DO
    Mnemonic := "RTE";
Op := {14, 11, 10, 9, 6, 5, 4, 1, 0};
AddrModeA := ModeA{};
AddrModeB := ModeB{};
  INC (i);
WITH Table68K[i] DO
Mnemonic := "RTR";
Op := {14, 11, 10, 9, 6, 5, 4, 2, 1, 0};
AddrModeA := ModeA{};
INC (i);
WITH Table68K[i] DO
Mnemon1c := "RTS";
Op := (14, 11, 10, 9, 6, 5, 4, 2, 0);
AddrModeA := ModeA();
AddrModeB := ModeB{};
INC (i);
WITH Table68K[i] DO
    Mnemonic := "SBCD";
    Op := {15, 8};
    Add:ModeA := ModeA{Rx911, RegMem3, Ry02};
    Add:ModeB := ModeB{};
 INC (i);
WITH Table66K[i] DO
Mnemonic := "SCC";
Op := {14, 12, 10, 7, 6};
AddrModeA := ModeA{;;
AddrModeB := ModeB[EA05e];
  INC (i);
WITH Table68K[i] DO
Mnemonic := "SCS";
Op := {14, 12, 10, 8, 7, 6};
AddrModeA := ModeA();
AddrModeB := ModeB(EAOSe);
END;
INC (1);
WITH Table68K[i] DO
    Mnemonic := "SEQ";
    Op := {14, 12, 10, 9, 8, 7, 6};
    AddrModeA := ModeA{};
    AddrModeB := ModeB{EA05e};
  INC (1);
WITH Table68K[i] DO
Mnemonic := "SGE";
Op := {14, 12, 11, 10, 7, 6};
AddrModeA := ModeA{};
END;
END;
 INC (1);
WITH Table68K[i] DO
    Mnemonic := "SGT";
    Op := {14, 12, 11, 10, 9, 7, 6};
    AddrModeA := ModeA{};
    AddrModeB := ModeB{EA05e};
   INC (1);
WITH Table68K[1] DO
Mnemonic := "SHI";
Op := {14, 12, 9, 7, 6};
AddrModeA := ModeA{};
AddrModeB := ModeB{EA05e};
   END:
 INC (1);

HITE Table68K[i] DO

Mnemonic: "SLE";

Op:= {14, 12, 11, 10, 9, 8, 7, 6};

AddrModeA: = ModeA{};

AddrModeB:= ModeB{EA05e};
   INC (i);
WITE Table68K[i] DO
Mnemonic := "SLS";
Op := {14, 12, 9, 8, 7, 6};
AddrMode8 := Mode8{2A05e};
    END:
    INC (1);
WITH Table68K[i] DO
Mnemonic := "SLT";
Op := {14, 12, 11, 10, 8, 7, 6};
AddIModeA := ModeA{;}
AddIModeB := ModeB{EA0Se};
END;
    INC (i);
WITH Table68X[i] DO
Mnemonic:= "SMI";
Op := {14, 12, 11, 9, 8, 7, 6};
AddrModeA := ModeA{};
AddrModeB := ModeB{EA05e};
                                                                   (continued on page 92)
```

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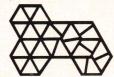
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#### **68K ASSEMBLER**

#### Listing Sixteen (Listing continued, text begins on page 44.)

```
INC (i);
WITH Table68K[i] DO
Mnemonic := "SNE";
Op := {14, 12, 10, 9, 7, 6};
AddirModeh := ModeA[;
END;

INC (i);
MITH Table68K[i] DO
Mnemonic := "SPL";
Op := {14, 12, 11, 9, 7, 6};
AddirModeB := ModeA[;
AddirModeB := ModeA[;
AddirModeB := ModeA[;
INC (i);
MITH Table68K[i] DO
Mnemonic := "STT;
Op := {14, 12, 7, 6};
AddirModeB := ModeA[;
INC (i);
MITH Table68K[i] DO
Mnemonic := "STO";
Op := {14, 12, 7, 6};
AddirModeB := ModeA[;
INC (i);
MITH Table68K[i] DO
Mnemonic := "STO";
Op := {14, 11, 10, 9, 6, 5, 4, 1};
AddirModeB := ModeA[;
END;

INC (i);
WITH Table68K[i] DO
Mnemonic := "SUB";
Op := {14, 11, 10, 9, 6, 5, 4, 1};
AddirModeB := ModeA[;
AddirModeB := ModeA[;
INC (i);
WITH Table68K[i] DO
Mnemonic := "SUB";
Op := {15, 12};
AddirModeB := ModeB[EA05a];
END;

INC (i);
WITH Table68K[i] DO
Mnemonic := "SUBA";
Op := {15, 12};
AddirModeB := ModeB[EA05a];
END;

INC (i);
WITH Table68K[i] DO
Mnemonic := "SUBI";
Op := {10, 12};
AddirModeB := ModeB[Size67, EA05e, Exten];
END;

INC (i);
WITH Table68K[i] DO
Mnemonic := "SUBO";
Op := {14, 12, 8};
AddirModeB := ModeB[Size67, EA05d];
END;

INC (i);
WITH Table68K[i] DO
Mnemonic := "SUBO";
Op := {14, 12, 8};
AddirModeB := ModeB[Size67, EA05d];
END;

INC (i);
WITH Table68K[i] DO
Mnemonic := "SUBO";
Op := {14, 12, 8};
AddirModeB := ModeB[Size67, EA05d];
END;

INC (i);
WITH Table68K[i] DO
Mnemonic := "SUBO";
Op := {14, 12, 8};
AddirModeB := ModeB[Size67, EA05d];
END;

INC (i);
WITH Table68K[i] DO
Mnemonic := "SUBO";
Op := {14, 12, 8};
AddirModeB := ModeB[Size67, EA05d];
END;

INC (i);
WITH Table68K[i] DO
Mnemonic := "SUBO";
Op := {15, 12, 8};
```

```
AddrModeA := ModeA{Rx911, RegMem3, Ry02};
AddrModeB := ModeB{Size67};
END;
INC (i);
WITE Table68K[i] DO
Mnemonic := "SVC";
Op := {14, 12, 11, 7, 6};
AddrModeB := ModeA{};
AddrModeB := ModeA{};
AddrModeB := ModeA{};
AddrModeB := ModeA{};
AddrModeA := ModeA{};
AddrModeA := ModeA{};
AddrModeA := ModeA{};
AddrModeB := ModeA{};
AddrModeA := ModeA{};
END;

INC (i);
WITE Table68K[i] DO
Mnemonic := "SWAP";
Op := {14, 11, 6};
AddrModeA := ModeA{Ry02};
AddrModeB := ModeB{};
END;

INC (i);
WITE Table68K[i] DO
Mnemonic := "TAS";
Op := {14, 11, 9, 7, 6};
AddrModeA := ModeA{};
AddrModeA := ModeA{};
AddrModeA := ModeA{};
END;

INC (i);
WITE Table68K[i] DO
Mnemonic := "TRAP";
Op := {14, 11, 10, 9, 6};
AddrModeA := ModeA{};
END;

INC (i);
WITE Table68K[i] DO
Mnemonic := "TRAPV";
Op := {14, 11, 10, 9, 6, 5, 4, 2, 1};
AddrModeB := ModeA{};
END;

INC (i);
WITE Table68K[i] DO
Mnemonic := "TRAPV";
Op := {14, 11, 10, 9, 6, 5, 4, 2, 1};
AddrModeB := ModeA{};
END;

INC (i);
WITE Table68K[i] DO
Mnemonic := "TST";
Op := {14, 11, 10, 9, 6, 5, 4, 2, 1};
AddrModeB := ModeA{};
END;

INC (i);
WITE Table68K[i] DO
Mnemonic := "TST";
Op := {14, 11, 10, 9, 6, 4, 3};
AddrModeB := ModeA{};
AddrModeB := ModeA{};
END;

INC (i);
WITE Table68K[i] DO
Mnemonic := "TST";
Op := {14, 11, 10, 9, 6, 4, 3};
AddrModeB := ModeA{};
AddrModeB := ModeA{};
END;

INC (i);
WITE Table68K[i] DO
Mnemonic := "TST";
Op := {14, 11, 10, 9, 6, 4, 3};
AddrModeB := ModeA{};
```

|   | 'OPCODE.DAT") # FileOK THEN<br>("Unable to create OpCode File."); |
|---|---|
| END;  |   |
| FOR i := FIRST WriteRec (f, END;                          | TO LAST DO Table68K[i]);  |
| <pre>IF Close (f) #    WriteString    WriteLn; END:</pre> | FileOK THEN ("Unable to close OpCode File.");                     |
| END InitOperation   | Codes.  |

#### **End Listing Sixteen**

(to be continued next month)

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## CRYPTOGRAPHER'S TOOLBOX

#### Listing One (Text begins on page 58.)

```
** cypher.c
                           File Cypher Program by F.A.Scacchitti 9/11/85
                            Written in Small-C Version 2.10 or later
                           Copies from original file to encrypted file using cypher key(s) passed to encode or decode.
#include <stdio.h>
#define BUFSIZE 16384
int fdin, fdout;
                           /* file i/o channel pointers */
int n, count;
char *inbuf, *key;
main(argc, argv) int argc, argv[]; {
    inbuf = malloc(BUFSIZE);
** Open file streams
 if(argc < 4) {
    printf("\ncypher usage: cypher <source file> <new file>
<key1> <key2> . . . <keyN> <CR>\n");
    if((fdin = fopen(argv[1],"r")) -- NULL) {
    printf("\nUnable to open %s\n", argv[1]);
        exit():
    if((fdout = fopen(argv[2],"w")) -- NULL) {
   printf("\nUnable to create %s\n", argv[2]);
/*
** Read file - encode it - Write new file
        printf("-reading file\n");
        count = read(fdin,inbuf,BUFSIZE);
        while(n++ <argc) {
  key = argv[n-1];
  cypher(inbuf,count,key);</pre>
        printf("-writing %d byte file\n\n", count);
        write (fdout, inbuf, count);
    } while (count - BUFSIZE);
    /* close up shop */
        fclose(fdin);
fclose(fdout);
```

**End Listing One** 

#### Listing Two

```
/* cypherl.c Cypher module by F.A.Scacchitti
**

** Simple cypher module - encodes directly with user keys

**/

#include <stdio.h>
static int i, n, keylength;
cypherl(buffer, num, code) char *buffer, *code; int num;{

/*
    ** get keylength for each key

*/
    keylength = 0; while(code[keylength++] != NULL);
    keylength--;

/*
    ** encrypt the file with each key

*/
    printf("-encoding/decoding buffer\n");
    for(i=0; i<-num; i++)
        buffer[i] = buffer[i] ^ code[i % keylength];
}</pre>
```

**End Listing Two** 

#### **Listing Three**

```
cypher2.c Cypher module
                                                                       by F.A.Scacchitti
10/11/85
           Complex cypher module - generates a key of some prime length between 1024 and 2028 bytes then encrypts the buffer with this key
**

**

**

**
#include <stdio.h>
#define NEWBUF 2000 #define NUMPRIMES 50
1033, 1973, 1039, 1951, 1049, 1949, 1051, 1933, 1061, 1931,
                              1063, 1913,
                                              1069, 1907,
                                                               1087
                              1901, 1091,
1097, 1877,
1871, 1117,
                                              1889, 1093, 1879,
1103, 1873, 1109,
1867, 1123, 1861,
                              1129, 1847, 1151, 1831, 1153, 1823, 1163, 1813, 1171, 1803);
cypherl (buffer, num, code) char *buffer, *code; int num; {
** allocate a buffer for the generated key
    newkey = malloc(NEWBUF):
** get keylength and sumcheck for each key
    keylength = sum = 0;
while((n = code[keylength]) != NULL) {
    sum += n;
        keylength++;
/*
** Select a prime and generate a new key that length
*/
    length = prime(sum & NUMPRIMES):
    printf("-generating a %d byte key\n",length);
    for(i=0; i<length; i++){
  index = i % keylength;
  sum = code[index] + sum & 255;
  newkey[i] = code[index] ^ sum;</pre>
** encrypt the file with the generated key
*/
    printf("-encoding/decoding buffer\n"):
    for (i=0; i<=num; i++)
        buffer[i] = buffer[i] ^ newkey[i % length];
   get rid of the buffer
    cfree (newkey);
```

#### **End Listing Three**

#### Listing Four

```
/* cypher3.c Cypher module by F.A.Scacchitti
11/09/85

**

** Complex cypher module - generates a key of some prime length
between 1024 and 2028 bytes then
encrypts the buffer with this key

**

if key starts with a '-' (dash)
calculate a transposition block size
and invert (transpose) the file in
this size blocks

**

define DASH 45
define NEWBUF 2000
define NUMPRIMES 50
```

(continued on next page)

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## CRYPTOGRAPHER'S TOOLBOX

#### Listing Four

(Listing continued, text begins on page 58.)

```
static int i, j, n, index, length, sum, keylength;
static char *tbuff, c;
static int prime[] = {1009, 1999, 1013, 1997, 1019
                                                     1031,
                             1993,
                                    1021, 1987,
                                                     1951,
                             1033.
                             1033, 1973, 1039, 1951,
1949, 1051, 1933, 1061,
                                                             1049
                             1063, 1913, 1069, 1907,
                                                             1087
                             1005, 1913, 1069, 1907, 1087, 1901, 1091, 1889, 1093, 1879, 1097, 1877, 1103, 1873, 1109, 1871, 1117, 1867, 1123, 1861, 1129, 1847, 1151, 1831, 1153, 1823, 1163, 1813, 1171, 1803};
cypher(buffer, num, code) char *buffer, *code; int num; {
 /*
** allocate a buffer for the new key or transposition
    tbuff = malloc(NEWBUF):
 ** get keylength and sumcheck for each key
    keylength = sum = 0;
while((n = code[keylength]) != NULL) {
    sum += n;
        keylength++;
 /*
** do we transpose or encode ?
    if((c = *code) = DASH)
         transpose (buffer, num, code);
    else
         encode (buffer, num, code);
    get rid of the buffer
    cfree (tbuff);
 ** Here's where we transpose
transpose (buffer, num, code) char *buffer, *code; int num; {
    length = (((sum + keylength) % 16) % 15) + 2:
    printf("-transposing file by %d\n",length);
    index = 0.
         for(i = 0; i < length; i++){
            j = length - i - 1;
tbuff[j] = buffer[index + i];
        for(i = 0; i < length; i++){
  buffer[index + i] = tbuff[i];</pre>
         index += length;
     }while(index < count);
 ** Here's where we encode
 encode (buffer, num, code) char *buffer, *code; int num; {
 ** Select a prime and generate a new key that length
     length = prime[sum % NUMPRIMES];
    printf("-generating a %d byte key\n",length);
     for(i=0; i<length; i++){
        index = i % keylength;
sum = code[index] + sum & 255;
tbuff[i] = code[index] ^ sum;
 ** encrypt the file with the generated key
    printf("-encoding/decoding buffer\n");
     for (i=0; i<=num; i++)
         buffer[i] = buffer[i] ^ tbuff[i % length];
                                                             End Listing Four
```

#### Listing Five

```
** fv.c
              File View/Compare Program
                                                    by F.A.Scacchitti 9/11/85
                           Written in Small-C Version 2.10 or later
                           Dumps contents of single file to screen
                           Dumps contents of 2 files and xored difference
                           Displays in hex and ascii form
#include <stdio.h>
#define BUFSTZE 1024
                          /* file i/o channel pointers */
int fdin1. fdin2:
int i, j, k, val, count, total, offset, numdisp; char *inbuf1, *inbuf2, *difbuf, c;
main(argc, argv) int argc, argv[]; {
    switch (argc) (
       inbuf1
                 = malloc(BUFSIZE):
       if((fdin1 = fopen(argv[1], "r")) == NULL) {
  printf("\nUnable to open %s\n", argv[1]);
            exit():
       numdisp = 1;
if(argc == 2) break;
    difbuf = malloc(BUFSIZE);
if((fdin2 = fopen(argv[2],"r")) == NULL) {
    printf("\nUnable to open %s\n", argv[2]);
            exit();
        numdisp = 3;
        break;
       printf("\nfv usage: fv <file1>
                               e: fv <filel> - dump file\n");
fv <filel> <file2> - compare 2 files\n");
        exit();
    total - offset - 0;
   printf("\n");
    do {
        count = read(fdin1,inbuf1,BUFSIZE);
        if(argc >= 3){
  read(fdin2,inbuf2,BUFSIZE);
            for(i=0; i < count; i++)
  difbuf[i] = inbuf1[i] ^ inbuf2[i];</pre>
        for(i=0; i < count; i+=16) {
            for(k=1; k <= numdisp; k++) {
                switch (k) {
case 2:
    offset = BUFSIZE;
                    break;
                    offset = 2 * BUFSIZE;
                break;
default:
                    offset = 0;
                    break;
                if(k < 3)
                    printf("f-%d", k);
                    printf("dif");
                printf(" %04x ",i+total);
                for(j=0; j<=15; j++){
  val = inbufl[i + j + offset];
  printf("%02x ",val < 0 ? val - 65280 : val);</pre>
                    if((c = bdos(6,255)) == 19){
   if((c = getchx()) == 3)
   exit();
                                                              /* hold on ^S */
                                                                /* exit on ^C */
                                                                /* continue on ^O */
                printf(" ");
                for(j=0; j<=15; j++) {
   c = inbuf1[i + j + offset];
   if(c > 31)
                    putchar(c);
else
if(c-0)
                            putchar (61);
                        else
                            putchar (94);
                printf("\n");
if(k == 3) printf("\n");
         total += count;
     } while(count - BUFSIZE);
```

(continued on next page)

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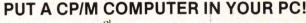
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## CRYPTOGRAPHER'S TOOLBOX

#### Listing Five

(Listing continued, text begins on page 58.)

```
/* close up shop */
fclose(fdin1);
if(argc == 3)
   fclose(fdin2);
```

**End Listing Five** 

#### Listing Six

```
/*
** fstat.c
                     File Statistics Program
                                                            by F.A. Scacchitti 10/8/85
                              Written in Small-C Version 2.10 or later
                               Scans file and displays distribution of
                               Calculates and displays mean, mode, median
                               and range of file.
Displays histogram of distribution.
#include <stdio.h>
#define BUFSIZE 16384
int fdin; /* file pointer */
int i, j, temp, value, count, total, *file, *sorted;
int sum, hisum, meansum, himeansum, mean, eflag, changing;
int median, oddmedian, range, min, max, mode;
int *data, scale;
main(argc, argv) int argc, argv[]; {
    if(argc < 2) {
   printf("\nfstat usage: fstat <input file>\n");
   exit();
     if((fdin = fopen(argv[1],"r")) -- NULL) {
   printf("\nUnable to open file %s\n",argv[1]);
         exit();
    inbuf = calloc(BUFSIZE,1);
file = calloc(256,2);
sorted = calloc(256,2);
data = calloc(17,2);
     eflag = FALSE;
sum = hisum = meansum = himeansum = mean = mode = j = 0;
     printf("reading the file-");
         count = read(fdin, inbuf, BUFSIZE):
         for(i=0: i < count: i++) {
             value = inbuf[i]:
             if(value < 0)
value = 256 + value;
             file[value]++;
if(++sum == 10000){
              if(++sum ===
hisum++;
             if ((meansum += value) >= 10000) {
                 himeansum++;
meansum -= 10000;
     } while (count - BUFSIZE):
/*
** Calculate the mean
*/
    printf("calculating mean-");
         if((meansum -= sum) < 0)
  if(himeansum > 0){
                 himeansum--;
meansum += 10000;
                 meansum += sum;
eflag = TRUE;
mean--;
         if ((himeansum -= hisum) < 0) (
         himeansum += hisum;
eflag = TRUE;
}else{
             mean++:
    }while(eflag == FALSE);
/*
```

```
** Calculate range, find mode min and max, fill the sorted array
    printf("calculating range-");
    min = max = file[0]:
    for(i = 0; i <= 255; i++){
  sorted[i] = file[i];
  if(file[i] > max){
    max = file[i];
  mode = i;
         if (file[i] < min)
              min - file[i];
    range = max - min + 1:
** Sort the sorted array to calculate median
     printf("sorting the array");
    changing - TRUE:
    while (changing) {
          changing = FALSE;
for(i = 0; i <= 254; i++)
    if(sorted[i] > sorted[i+1]){
                   temp = sorted[i];
sorted[i] = sorted[i+1];
sorted[i] = temp;
changing = TRUE;
              1
     }
    median = (sorted[128] + sorted[127]) / 2;
oddmedian = (sorted[128] + sorted[127]) % 2;
** Display the results
     printf("\n
     for(i = 0; i <= 255; i++) {
    printf("%5d", file[i]);</pre>
          chkkbd();
     printf("\n %d%04d characters read from file %s\n",
                                                              hisum, sum, argv[1]);
     hisum, sum, argv[1]);

printf("file mean = %d ",mean);

if((himeansum || meansum) > 0)

printf("%d%04d/%d%04d",himeansum,meansum,hisum,sum);

printf(" mode = %d (%x hex)", mode, mode);
     printr(" mode = %d ( %x he
printf("\n");
printf("file median = %d", median);
if(oddmedian)
    printf(" 1/2 ");
     printf(" ");
printf(" file range = %d [ min = %d
                                                                             max = %d ] \n",
     printf("\nDepress spacebar to display histogram ");
getchar():
     getchar();
     Sum the data in 16 groups of 16 elements and find max. value
     max = 0;
for(i = 1; i <= 16; i++) {
  for(j = 0; j <= 15; j++)
      data[i] += file[(i - 1) * 16 + j];
  if(data[i] > max)
               max = data[i];
/*
** Calculate scaling for plot
      scale - max / 50;
     scale = max / 50;
temp = max % 50;
if(temp / scale > 7)
scale++;
printf(" scale = %4d\n\n", scale);
 ** Print data and plot of histogram
     for(i = 0; i <= 15; i++){
printf(" %3d to %3d = %5d ||",i * 16, (i * 16) + 15,
data[i + 1]);
          temp = data[i + 1] / scale;
if(data[i + 1] % scale > 0)
    temp++;
while(temp-- > 0)
    printf("*");
printf("\n");
/*
** close up shop
*/
     fclose(fdin);
```

(continued on next page)



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#### Listing Six

(Listing continued, text begins on page 58.)

```
chkkbd() { char c;
     if((c = bdos(6,255)) == 19)
  if((c = getchx()) == 3)
  exit();
                                                            /* hold on ^S */
                                                              /* exit on ^C */
/* continue */
```

**End Listing Six** 

#### Listing Seven

```
File Generator Program
    makef.c
                                                             by F.A. Scacchitti 10/7/85
                              Written in Small-C Version 2.10 or later
                              Creates a segential file of characters from 0 to 255 in blocks of 255 bytes. The sequential characters can be replaced with any single character desired.
#include <stdio.h>
#define BUFSIZE 256
                               /* file i/o channel pointers */
int i, n, num;
char *outbuf, value;
main(argc, argv) int argc, argv[]; {
 ** Allocate memory for buffer
    outbuf = malloc(BUFSIZE);
/*
** Check arguments passed and open file stream
    if(argc < 3) {
   printf("\nmakef usage: makef <new file> <nnnn> [ddd]\n");
   printf(" nnn = file size in 256 byte blocks\n");
   printf(" ddd = optional alternate value in decimal\n");
    if((fdout = fopen(argv[1],"w")) -- NULL) {
   printf("\nUnable to create %s\n", argv[1]);
/* '
** Convert file size argument to integer
    if ((n = atoi(argv[2])) == NULL) exit();
/*
** Fill the buffer with 0 to 255 sequence
*/
     for(i = 0; i <-255; i++)
outbuf[i] = i;
** Refill the buffer with a single character if directed by argument
    if (argc == 4)
         if((value = atoi(argv[3])) < 256)
for(i = 0; i <=255; i++)
    outbuf[i] = value;</pre>
/*
** Write blocks to file
    for(i=1; i <= n; i++)
  if((num = write(fdout,outbuf,BUFSIZE)) < BUFSIZE) exit();</pre>
** Close up shop
    fclose(fdout);
```

**End Listing Seven** 

#### Listing Eight

```
** sp.c
                 Search Pattern Program by F.A. Scacchitti 10/15/85
                    Written in Small-C Version 2.10 or later
                    Searches file for repetitive pattern.
```

```
#include <stdio.h>
#define BUFSIZE 16384
main(argc, argv) int argc, argv[]; {
** Set defaults
   block = 128;
depth = 4;
start = 0;
/*
** Allocate memory for buffer
   inbuf = malloc(BUFSIZE);
/*
** Check arguments passed and open file stream
   exit():
   if((fdin - fopen(argv[l],"r")) -- NULL) {
  printf("\nUnable to open %s\n", argv[l]);
  exit();
** Convert optional inputs to integer and implement
   if(argc > 2)
  if((n = atoi(argv[2])) != NULL)
  block = n;
   if(argc > 3)
   if((n = atoi(argv(3))) != NULL)
   depth = n;
   if(argc > 4)
   if((n = atoi(argv[4])) != NULL)
     start = n;
/*
** Fill the buffer with as much as possible
*/
    count = read(fdin,inbuf,BUFSIZE);
    limit - count - depth;
/*
** If there's a sixth argument, convert the file to numerical sequence
    if(argc > 5) {
  for(i = 0; i < count = 1; i++)
    inbuf[i] = inbuf[i + 1] = inbuf[i];</pre>
   /*
** Close up shop
    printf("\n");
                       /* Flush print buffer */
    fclose(fdin);
 chkdepth (pointer, offset, k) int pointer, offset, k; {
     while(inbuf[pointer] -- inbuf[offset] && k < count) (
        pointer++
offset++;
     return(k);
 chkkbd() (
     if((c = bdos(6,255)) -- 19)(
   if((c = getchx()) -- 3)
   exit();
                                        /* exit on ^C */
                                         /* continue */
```

**End Listings** 

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#### 16-BIT

#### Listing One (Text begins on page 106.)

```
window
                       page
                                   BIOS Window Extension V1.1
comment
                       Copyright 1984 John J. Seal
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                       348 East Pratt Street
                       Franklin, IN 46131
                       This program may be used for any non-commercial purpose provided that this copyright notice is included. Commercial use is forbidden without the express written consent of The Graphic Software Company.
                       This program allows a window to be defined on the display. All programs which use the BIOS Write TTY call for output
                       will work within the window. Other BIOS calls may still be
                       used for I/O to arbitrary screen positions.
                       The window is defined by a pair of coordinates specified on
the command line. The only absolute format requirements are
that each coordinate pair start with a left parenthesis and
be separated with a comma. Everything else is optional. The
suggested command format is:
                       window (ur, lc) to (lr, rc)
                       ur = upper row
lc = left column
                       lr = lower row
                       rc = right column
                       The new functions serviced by the video interrupt (int 10)
                       and their corresponding function codes are:
                       ah = 14 Write TTY
ah = 16 Set window coordinates
ah = 17 Get window coordinates
                       ah = 18 Get blanking attribute
code
                       segment
                                   100h
                                                                                  : For COM conversion
                       assume cs:code
DOS entry
                       label
                                                                                  ; DOS entry point
                                   install
                       qmt
upper_left
left
                       label
                                   word
                                                                                  ;Window coordinates
                       db
upper
lower_right
                       db
                       label
                                   word
79
right
lower
                                   24
old int
                                                                                 ;Old interrupt vector
comment
                       The new interrupt procedure first filters out the new
                       services from the old, and passes all old service calls
                       back to the BIOS.
interrupt
                       proc
                                   far
                       amp
                                   ah. 14
                                                                                  ;Write TTY
                       je
                                   write tty
                                   ah,16
                                                                                  ; Set window
                       ie
                                   set window
                                   ah, 17
                       amp
                                                                                  :Get window
                                   get_window
ah, 18
                       je
amp
                                                                                  :Get blanking
                                   get blanking
bios:
                                   old int
                       dmt
comment
                       Set window coordinates.
```

This function call sets the coordinates of a window in the display area. The window is defined by specifying the upper left and lower right corners in terms of screen coordinates. The upper left corner of the screen is position (0,0). The specified corners are included in the window area.

If the specified coordinates are legal then the window is cleared, the cursor is homed to the upper left corner, and al = 0. Otherwise, no action is taken and al = 1.

```
Entry: ah = 16 (function code)
                                  cx = upper left corner
dx = lower right corner
al = fail flag (see above)
                       All registers preserved except ax.
 set_window:
                        push
                                                                                ; Save registers
                        push
                                   cx
dx
                        push
                        mov
                                   al, 1
                        amp
                                   ch, dh
                                                                                :Check coordinates
                                   exit
                        ja
                        cmp
ta
                                   cl, dl
                                   exit
                                   upper left, cx
                                                                                :Update coordinates
                        mov
                                   lower_right, dx ah, 18
                        mov
                                                                                :Read blank attribute
                                   10h
                        int
                                   ax, 600h
                        mov
                                                                                ;Blank entire window
                        int
                                   10h
                                   ah, 15
                        mov
                                                                                ; Read current page
                        int
                                   10h
                        mov
                                   dx, cx
                                                                                : Home cursor
                        mov
                                   ah, 2
                                   10h
                        mov
                                   al,0
 exit:
                                   dx
                                                                                ; Restore registers
                        pop
                                   CX
 comment
                        Get window coordinates.
                       This function call returns the coordinates of the upper left and lower right corners of the current display window.
                        Entry: ah = 17 (function code)
                                  cx = upper left corner
dx = lower right corner
                       All registers preserved except cx and dx.
 get window:
                       mov
                                  cx, upper_left dx, lower_right
                                                                                ; Read coordinates
                       iret
 comment
                       Get blanking attribute.
                       This function call returns the attribute of the character
                       at the current cursor position, if in alpha mode, or the background color (0) if in graphics mode. The resulting attribute is meant to be used when scrolling the screen.
                       Entry: ah = 18 (function code)
Exit: bh = blanking attribute
                       All registers preserved except bx.
get blanking:
                       push
                                                                                ; Save registers
                       mov
                                  ah, 15
                                                                               ; Read current page
                                  10h
                       int
                       xor
                                  ah, ah
                                                                                :Background color
                       cmp
jbe
                                  al.3
                                                                                ;Check for alpha modes
                                  alpha
                       amp
jbe
                                  al, 6
                                                                                ; Check for graphics
                                  graphics
alpha:
                       mov
                                  ah,8
                                                                               :Read attribute
                       int
                                  10h
graphics:
                       mov
                                  bh, ah
                                                                               ;Return attribute
                       pop
comment
                      Write TTY.
                      This function call replaces the old call of the same name. It performs the same functions but allows the current window to be user defined instead of the whole screen.
                      Entry: ah = 14 (function code)
al = character to write
bh = page number to write on
bl = foreground color (in graphics modes)
                      All registers preserved.
write_tty:
                      amp
                                                                               ; Let BIOS ring the bell
                                                                                     (continued on next page)
```

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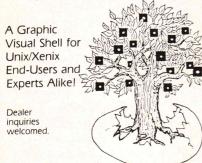
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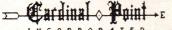
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int

10h

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#### 16-BIT

#### (Listing continued, text begins on page 106.)

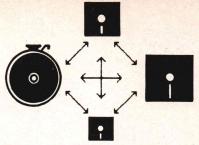
|             | push   | ax   | ; Save registers                       |  |  |  |  |
|-------------|--|--|--|--|--|--|--|
|             | push   | bx<br>cx   |  |  |  |  |  |
|             | push   | dx   |  |  |  |  |  |
|             | push   | ax   | ; Save character                       |  |  |  |  |
|             | mov  | ah,3<br>10h  | ;Read cursor position                  |  |  |  |  |
|             | pop  | ax   | ;Recover character                     |  |  |  |  |
|             | Check for unprintable control characters   |  |  |  |  |  |  |
|             | Check for unprintable control characters   |  |  |  |  |  |  |
|             | cmp  | al,8   | ; Backspace                            |  |  |  |  |
|             | je<br>cmp  | al,10  | ;Line feed                             |  |  |  |  |
|             | je   | lf   | ·Carriago rotura                       |  |  |  |  |
|             | cmp<br>je  | al,13<br>cr  | ;Carriage return                       |  |  |  |  |
|             |  |  |  |  |  |  |  |
|             | Character is printable   |  |  |  |  |  |  |
|             | mov  | cx,1   | ;Print character                       |  |  |  |  |
|             | mov<br>int   | ah, 10<br>10h  |  |  |  |  |  |
|             | inc  | dl   | ;Advance cursor                        |  |  |  |  |
|             | cmp<br>jbe   | dl, right set cursor   |  |  |  |  |  |
|             |  |  |  |  |  |  |  |
| ;           | Right edge of window exceeded - wrap to next line  |  |  |  |  |  |  |
|             | mov  | dl,left  |  |  |  |  |  |
| lf:         | inc  | dh lower   |  |  |  |  |  |
|             | cmp<br>jbe   | dh, lower<br>set cursor  |  |  |  |  |  |
|             | Tour   | - adap of window exceeded - scroll   | window up                              |  |  |  |  |
|             | Lower edge of window exceeded - scroll window up   |  |  |  |  |  |  |
|             | push   | bx   | ;Save page<br>;Read blank attribute    |  |  |  |  |
|             | mov  | ah, 18<br>10h  | , Read Diank accribace                 |  |  |  |  |
|             | MOV  | cx, upper_left   | ;Scroll window up                      |  |  |  |  |
|             | mov  | dx,lower_right ax,601h   |  |  |  |  |  |
|             | int  | 10h  |  |  |  |  |  |
|             | pop  | bx   | ;Restore page                          |  |  |  |  |
| ;           | Return   | cursor to left-hand edge   |  |  |  |  |  |
| ar.         | mov  | dl,left  | ;Carriage return                       |  |  |  |  |
| cr:         | mov  | ui, ieit   |  |  |  |  |  |
| ;           | Set cursor to new position   |  |  |  |  |  |  |
| set cursor: | mov  | ah, 2  | ;Set cursor                            |  |  |  |  |
|             | int  | 10h  | ;Restore registers                     |  |  |  |  |
|             | pop  | dx<br>cx   | , Kestora regression                   |  |  |  |  |
|             | pop  | bx   |  |  |  |  |  |
|             | pop  | ax   |  |  |  |  |  |
|             |  | last ada   | of udadou                              |  |  |  |  |
| ,           | Backsp   | ace does not wrap past left edge   | of window                              |  |  |  |  |
| bs:         | dec  | dl   | ;Back up                               |  |  |  |  |
|             | cmp<br>1b  | dl,left<br>cr  | ;Past left edge?<br>;Yes, reset cursor |  |  |  |  |
|             | dmc  | set_cursor.  | ; No, leave it alone                   |  |  |  |  |
| interrupt   | endp   |  |  |  |  |  |  |
| Incerrupe   |  |  |  |  |  |  |  |
| greeting    | db<br>db   | 13,10<br>218,30 dup (196),191,13,10  |  |  |  |  |  |
|             | db   | 179 ' The Granhic Software Com   | pany ',179,13,10                       |  |  |  |  |
|             | db<br>db   | 179, BIOS Window Extension V<br>192,30 dup (196),217,13,10,'\$'  | 71.1 ',179,13,10                       |  |  |  |  |
|             | un un  |  |  |  |  |  |  |
| error_msg   | db   | 13,10, 'Invalid window coordinate  | ates',13,10,'\$'                       |  |  |  |  |
| comment     | 1  |  |  |  |  |  |  |
|             | The in   | stall procedure is invoked throu   | igh the DOS entry point                |  |  |  |  |
|             | The install procedure is invoked through the DOS entry point when the program is first run. It installs the new interrupt    |  |  |  |  |  |  |
|             | and pr   | and prints a message on the console. When done, it returns to DOS and allows the space it occupies itself to be reclaimed. |  |  |  |  |  |
|             |  |  |  |  |  |  |  |
|             | The program first tests whether the BIOS extensions are already installed. If they are not, this can be detected by the fact |  |  |  |  |  |  |
|             | that a call to an illegal function will return without altering  |  |  |  |  |  |  |
|             | any re   | gisters.   |  |  |  |  |  |
|             | 1  |  |  |  |  |  |  |
|             | assume   | ds:code  |  |  |  |  |  |
|             |  |  |  |  |  |  |  |
| install     | proc   | near<br>ah, 17   | ;Read coordinates                      |  |  |  |  |
|             | int  | 10h  |  |  |  |  |  |

:Alter their value

al, cl mov int 10h ; Read them again al, cl ;Test for difference CITIO pushf installed jne Install BIOS extensions dx, offset greeting mov ; Report installation mov int 21h ax, 3510h mov ; Read old interrupt int word ptr old int,bx word ptr old int+2,es dx,offset interrupt mov ; Save old interrupt mov mov ;Install new interrupt ax, 2510h mov BIOS extensions are installed now installed: push ;Point to command tail pop di,81h cx,7fh al,'(' mov mov :Read coordinates mov repne call scasb ;Find first pair num\_pair push repne scash ;Find second pair num\_pair pop ah. 16 mov :Set coordinates int 10h al, al ;Test legality jz legal Window coordinates are illegal dx, offset error msg mov ;Print error message int Terminate program in appropriate manner legal: popf ;Check residency ine resident mov dx, offset greeting :Make resident intresident: int 20h ;Already resident num pair proc near push bx :Read first number call number bh, dl mov call :Read second number mov dh, bh pop bx ; Row/Col pair in dx num\_pair endp proc near push push ax bx al,' :Skip leading blanks mov repe dec scasb ;Decimal multiplier mov bl, 10 xor ax, ax dx, dx xor ;Multiply by 10 xchg digit: ax, dx bl mul ; Add new digit add ax, dx xchg al, es: [di] : Read next character mov inc al, '0' al, '9' :Normalize it sub ;Check for digits cmp jbe pop bx pop ax :Number in dx ret number endp endp ends code :Must be far label DOS\_entry end

**End Listing** 

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#### **MS DOS Reference Books**

A lthough books on 8086/88 assembly-language programming abound, books on programming in the MS DOS environment have been nearly nonexistent. Several new books on this subject have appeared recently, however, and I would like to mention a few I have looked at:

Simrin, Steven. *MS-DOS Bible*. Indianapolis: Howard W. Sams & Co., 1985. 385 pages with index.

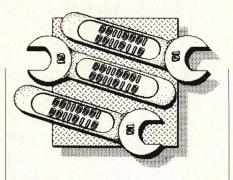
I would characterize this as an introductory systems guide to MS DOS. Exposition of the MS DOS hierarchical file structure, I/O redirection and pipes, installation of a fixed disk, batch files, the MS DOS intrinsic and extrinsic commands, and use of *ED-LIN*, *LINK*, and *DEBUG* comprise the majority of the book. Two brief chapters discuss disk formats, directories, the file allocation table, and device drivers; the actual MS DOS function calls are relegated to an appendix. The book contains virtually no programming examples.

Jump, Dennis N. *Programmer's Guide to MS-DOS*. Bowie, MD: Brady Communications Co., 1984. 244 pages with index.

Although this book carries a 1984 copyright date, I did not see it in the bookstores until a few months ago. It is aimed at beginning assembly-language programmers and discusses the various MS DOS function calls by category (traditional character I/O calls, traditional file management calls, extended file management calls, and so on). There is minimal coverage of MS DOS loading, structure, or disk control areas. The expla-

#### by Ray Duncan

nations of memory management, the MS DOS *EXEC* call, and installable device drivers are reasonable though incomplete. The last 30 or so pages of



the book are devoted to IBM PC-specific topics, mainly the ROM BIOS driver calls. Programming examples are chiefly in the form of assembly-language functions to be called from Pascal, except for an example character device driver. This book, together with the MS-DOS Bible by Simrin would be a good starting point for beginning MS DOS assembly-language programmers as the two books have little overlap in content.

King, Richard A. *The MS-DOS Hand-book*. Berkeley, CA: Sybex Computer Books, 1985. 319 pages with index.

This book is written for beginning assembly-language programmers; it covers most of the same material as the previous two books combined except that disk structures and control areas are discussed in a rather general way and device drivers are barely mentioned. It contains few programming examples. My biggest complaint about this book is that material applicable to generic MS DOS systems and material pertinent only to IBM PCs is jumbled together with very little distinction.

Norton, Peter. The Peter Norton Programmer's Guide to the IBM PC. Bellevue, WA: Microsoft Press, 1985. 426 pages with index.

As you would expect, this book is heavily slanted toward the IBM PC family with extensive discussion of the IBM video adapter, keyboard, sound generation, and ROM BIOS. It may best be viewed as a well-organized, highly readable replacement for both the IBM PC DOS Technical Reference and the IBM PC Hardware Reference

ence manuals. It's directed at programmers of intermediate experience.

Information on the generic MS DOS services occupies less than a quarter of Norton's book but is still relatively thorough; additional quick-reference tables are well laid out. The book has clear explanations of the MS DOS disk structure and control areas, file control blocks, and program segment prefixes. The section on the EXEC function is inadequate to make it work (unless the reader already knows how) because the special use of the modify memory block function 4ah with register ES pointing to the calling program's PSP is not detailed; also, the author's comment on registers destroyed by EXEC and the method of saving and restoring the SS and SP registers are not correct. Coverage of device drivers is limited to some discussion and (deserved) criticism of ANSI.SYS; there is no material on the structure or programming of device drivers. Assembly-language examples are sparse and simplistic and are nearly all from the point of view of Pascal or C subroutines.

Lafore, Robert. Assembly Language Primer for the IBM PC and XT. New York: New American Library, 1984. 501 pages with index.

Like the Norton book, this book is strongly biased toward the IBM PC hardware and ROM BIOS software, but about a quarter of it is devoted to discussion of general MS DOS topics. The layout of DOS and the structure of executable program files are discussed briefly. File I/O is well covered, but advanced subjects such as device drivers, memory allocation, and the EXEC call are completely absent. This book makes extensive use of hex memory dumps and assembly-language examples, including complete working programs—a style that should be commended.

MS-DOS Programmer's Reference.

Bellevue, WA: Microsoft Press, 1984.

This book is rarely seen in its original Microsoft form. It is, however, commonly available in various MS DOS OEM editions, the most prevalent (of course) being the IBM PC DOS Technical Reference. Versions are also extant from Hewlett-Packard, Zenith, and Intel, among others. The Intel book is the best of the bunch; it has been extended with assembly-language examples for each MS DOS system function, source code for simple block and character device drivers, and a lengthy appendix describing the Intel relocatable object record format. It can be ordered from the Literature Department, Intel Corp., 3065 Bowers Ave., Santa Clara, CA 95051 (part number 135555-001).

DDJ readers are invited to send further comments on the above books to this column and to provide information on other books they have found useful. Two additional books on MS DOS programming, aimed at intermediate to advanced assembly-language programmers, are due from Microsoft Press about the time this column will appear in print. The first is my own book Advanced MS-DOS. The other is the MS-DOS Technical Reference Encyclopedia, Volume I (collaboration of several authors, preface by Bill Gates, about 1200 pages, \$134.95, June publication date expected).

#### The EXEC Function and FORTRAN

Chris Dunford, author of the popular CED command line editor, sent a comment on the interface between FOR-TRAN and the EXEC call that was printed in the January 1986 16-Bit Toolbox: "I wonder if you're aware that there is an easier way to find the PSP of a program: DOS function 62h returns (in register bx) the PSP address of the currently executing process. Function 62h is not available under DOS 2.x, but undocumented function 51h performs the same service. You want to avoid using undocumented features, of course, but I don't foresee new releases of DOS 2.X in the near future!

"It seems to me quite safe to check the DOS version under which your program is running, then use function 51h or 62h as appropriate. Of course, another advantage of this method over Sybek's is that it's compiler independent."

#### The 20 Files Problem

Dan Daetwyler's description of his problem with DOS' limit of 20 open files per process, which appeared in the December 1985 16-Bit Toolbox column, provoked several helpful responses from DDJ readers.

Sean McDowell of Marietta, Georgia, said: "I am writing in response to Mr. Daetwyler's letter about DOS 3.0 and the 20 file handle limit. We have

had this problem since handles were first introduced. I am very curious about why Mr. Daetwyler didn't run into this problem sooner. The problem seems to stem from the amount of room available in the program segment prefix (PSP). If you look at the memory map of the PSP in the IBM Technical Reference, there is an area from offset 18h to 2bh marked as reserved. This appears to be where DOS stores the allocated file handle numbers. Because there are 20 bytes, there are 20 file handles for the cur-

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16-BIT (continued from page 107)

rent process. DOS seems to use the segment address of the current PSP (see DOS 3.0 function 62h) as the process ID. Because an interrupt to a resident database-handling module would not change this value, that would explain why splitting the database and allowing the resident task to own part would not correct the problem. . . . Currently we are opening and closing handles with a least-recently-used algorithm within our file access routines, even though that can be painfully slow at times."

Inspecting the PSPs of some of my own programs, it does seem evident that the PSP handle table positions correspond to handle numbers. The byte at a given table position contains 0FFH if the handle is not in use for the process. If the handle is opened to a file or device, the byte contains a small integer number that is probably an index to DOS' internal table of file control blocks for the "extended" file functions.

Ross Nelson of San Jose, California, took this a little further: "The DOS equivalent of the process ID is the PSP paragraph number. This is how DOS keeps track of who owns memory blocks, and I suspect it manages open files in this way as well. It keeps an internal variable to track the 'currently active PSP,' and there are two (undocumented naturally) calls to get/set this variable.

"Executing an *interrupt 21h* with ah=51h will return the currently active PSP in the bx register. Loading bx with a PSP and executing an *interrupt 21h* with ah=50h will set a new active PSP. The pseudotasking solution to the file problem is then handled in this way:

Task A: open initial files, do processing, EXEC Task B

Task B: open new files, call (via software interrupt?) to Task A

Task A: save active PSP, set active to Task A's PSP, do processing, restore previous PSP, return Task B: continue processing. . ."

An unsigned note from another reader, along with a labeled hexadecimal dump of a program segment prefix, also took Mr. McDowell's ob-

servation on the PSP a little further. The anonymous reader pointed out that the words at PSP+0032h, 0034h, and 0036h contain the maximum number of handles allowed for the process, the offset of the handle table, and the segment of the handle table, respectively. The note said: "To open more than 20 handles, provide an area in your program consisting of one byte per handle. Move the first five handles from the table at PSP + 0018h to the new handle table. Then, change the handle table pointers at PSP + 0034h to point to the new table, and change the value at PSP + 0.032h to the number of entries in the new table."

#### PC/AT Interrupts

Brett Salter of Data Base Decisions wrote: "In regard to the AT problem you mentioned in your May 1985 column, I'm afraid Intel's nasty habit of referring to interrupt numbers as decimal instead of hex has caused some confusion. *Interrupt 13* decimal (not hex) is the segment overrun exception interrupt. Because this interrupt (0dh) was not previously used, it won't cause anything as disastrous as zapping a hard disk.

"IBM has most of the new exception interrupts vectored to a routine that sets a flag and then *IRET*s back to the user's program. On return, the instruction that caused the exception is reexecuted, putting the system into an enabled loop. The only way out on a normal PC/AT is to use Ctrl-Alt-Del to reboot.

"If you have my Periscope debugger installed on an AT, interrupts *0dh* (segment overrun) and *06h* (invalid opcode) point to Periscope. This means that the instruction sequence shown in your column will put the user into Periscope, where you can modify the registers as needed to recover the system.

"Another new twist on the PC/AT—if your program uses the array BOUND instruction, an exception causes INT 5 to be performed, printing the screen to a parallel printer. Then control returns to the BOUND instruction that caused the interrupt, which prints the screen over and over until you reboot the system. Once again, Periscope can be set to intercept this interrupt, letting you regain control of the system."

#### Macro Assembler, Version 4.0

The new speedy Version 4.0 of the Microsoft Macro Assembler also has a completely new bug! It seems that the include function has been changed in such a way that it ignores end-of-file marks (1ah) and uses the size of the file as recorded in the disk directory instead. If you use an editor (such as WordStar in nondocument mode), which rounds the size of the file up to the next block boundary and pads the last block out with EOF marks, you will get an "extra characters on line" error for the include statement. The listing file cannot be typed or printed past the point of the error because the macro assembler copies all of the extra EOF marks into the listing file! A work-around suggested by Microsoft is to invoke ED-LIN with the name of the source file. then enter the E command to immediately exit from the line editor. ED-LIN will scan for the first EOF mark and create a new file with the correct size, renaming the original file with a BAK extension.

#### IBM PC Window Control

John J. Seal, of the Graphics Software Co., contributed a resident window manager for the IBM PC to this month's 16-Bit column (see Listing One, page 102). The program is invoked with a command in the form:

C>WINDOW (R,C) TO (R,C)

which specifies a window on the screen in which all subsequent activity will take place. The window coordinates are given as the upper-left and lower-right row and column. Coordinate (0,0) is the upper-left corner of the screen.

WINDOW makes itself resident and captures the IBM BIOS video driver interrupt, filtering out some calls and passing the others on to the ROM driver. The areas outside the current window may be written to directly by any of the usual commands (in your favorite language) that allow direct coordinate specification; the WINDOW program affects only characters that are displayed with the "TTY Output" ROM BIOS call (function 0eh). The WINDOW program illustrates several useful PC DOS programming techniques:

- installation of a new resident process with the *terminate* and stay resident function
- chaining on to an existing interrupt handler
- using the MS DOS get interrupt and set interrupt functions to inspect and modify the hardware interrupt table

Although I have not changed Mr. Seal's code, it should be noted that the preferred method to terminate and stay resident for DOS, Version 2 and later, is use of *interrupt 21h* func-

tion 31h, rather than interrupt 27h. Similarly, the preferred method of final exit is now interrupt 21h function 4ch, rather than interrupt 20h.

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#### (Listing begins on page 102.)

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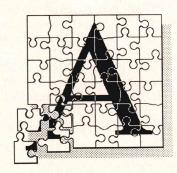
#### **Code Compression with Mini-Interpreters**

ode crunching is an arcane art, something like squeezing elephants into phone booths. When I was a game designer at Atari, I constantly had to squeeze my 6502 code down further and further to fit into a pitifully small 4K ROM space. Even after Atari invented a bank-switching ROM cartridge, we still came up against the memory limit very quickly. One of our sayings was that it's always possible to squeeze another byte out of an assembly-language program. Some of the feats we accomplished were truly remarkable—the world's smallest chess program (as far as I know) runs on the 2600 VCS game machine with only 4K of ROM and 128 bytes of RAM! When I left Atari, I thought I would never have to worry about crunching my code again. I was entering the world of "big" machines, with huge 64K RAM spaces! That was at best a very temporary release, though. Soon I was dealing with truly "enormous" programs (operating systems), and once again I had to start crunching my code.

Some of the techniques for effective code crunching are actually quite simple—for example, variables can frequently be moved into low memory, where most processors can access them with fewer bytes of address information. On the 6502 this is a particularly large saving—an instruction that loads a byte from memory location \$1000 requires 3 bytes, but if you load the information from \$10 you use up only 2. Another

#### by Nick Turner

trick is to use register variables wherever possible because register instructions are usually shorter. On the first crunching pass, though, all these simple tricks are usually used up. At Atari, this first pass usually reduced



the size of the game program by no more than 15 percent. Because the "raw" programs were about twice as large as the space into which they had to be shoehorned, there was still a lot of crunching to be done.

#### Using a Mini-Interpreter

The technique I'll talk about here was used with some success in many of my operating system designs. It's best applied when you have a lot of code that contains repetitive calls to several different subroutines. In one particular case, I was writing a system that would be accessed over the phone by users with serial terminals. It was important to be able to transmit various sequences of control characters and also to be able to receive and interpret similar sequences, setting and clearing various flags and changing the modes of input and output. To do this with traditional code would have worked, but I managed to chop the size of the required code by more than half using what I call a mini-interpreter.

A mini-interpreter is a subroutine that pops the stack to find out where it was called from, then reads the bytes immediately following the calling instruction and performs various tasks based on what is sees there. At some point it will see a *return* token and will perform a jump to the next valid instruction following. In the case of a machine in which the instructions must be word-aligned, such as the 68000, it would return to the next even-addressed byte.

The mini-interpreter I wrote for my dial-up system was originally created as a print routine that would read an ASCII string immediately after the invoked instruction, then print it out. A null (\$00) was used to terminate the string. (A 6502 routine by Chris Espinoza that does just this was published in the September 1976 issue of *DDJ*.) Here's a typical calling sequence for the routine as described so far:

... ;code preceding the call

JSR PRINT ;call the print
routine

ASC "This text would be printed out."

HEX 00
... ;code following the call

Note that the calling sequence requires 4 bytes; 3 for the *JSR* instruction and 1 for the null-token terminator. I felt that this 4-byte overhead was excessive. How could I shave it down?

The answer occurred to me one day while I was setting a breakpoint to debug a program: The BRK instruction, which is used by debuggers to wrest control from the executing program when it reaches a \$00 in the program, occupies only 1 byte and can cause execution to vector to any point in memory. The only problem was that the BRK instruction was used extensively during debugging. So, I created a conditional macro that would assemble the PRINT call as a JSR or a BRK, depending on whether I was debugging or not. Then I added a small routine in the initialization that placed the address of my PRINT routine into the BRK vector. Of course, the PRINT routine itself also had to have some conditionally assembled code because the BRK instruction puts some status information on the stack that I needed to pop and ignore. Only a few extra instructions were needed, however. The new method worked beautifully. Now I could

print any text I wanted with only a 2-byte overhead. Of course, the routine that handled the *PRINT* calls took up some space of its own, but with dozens of calls in my code, the extra overhead was more than compensated for by the code savings in my *PRINT* calls.

#### **Further Refinements**

I was quite pleased with the results, but I still needed to shave the program down further. I discovered that there were about a dozen macro expansions that frequently occurred adjacent to the PRINT calls. Many of them were used to set, test, or clear various print format flags-for example, there was a protocol with which the user could send a Control-C to inhibit furthur output until the beginning of the next logical block of text. To implement this protocol, I created an output-inhibit flag and tested the status of the flag before sending each character. The flag was reset at the beginning of each block of text and set whenever a Control-C was detected from the user. The problem was that the flag reset often occurred in the middle of a stream of text, requiring a code sequence something like this:

|       |             | text being output   |
|-------|-------------|---------------------|
| ASC   | "The last   | text in the first   |
|       |             | block."             |
| HEX   | 00          | ;marks end of text  |
| LDA   | TXTFLAG     | ;clear output sup-  |
|       | TXTFLAG     | press flag          |
| AND   | #255-OUTS   | SUP                 |
| STA   | TXTFLAG     |                     |
| PRINT |             | ;macro that in      |
|       |             | vokes print inter-  |
|       |             | preter (JSR or BRK) |
| BRK   |             |                     |
| ASC   | "First text | in the next block." |

Look at all those bytes! Including the end token of the previous block, the code to clear the flag, and the *BRK* to call the interpreter again, I used up 8 bytes! How could I cut that down?

more text

The answer became obvious as soon as I realized that the text-output interpreter could easily be increased in size without adding very much to the overall size of the program. Because there were quite a few 8-bit values that could never be encountered in the middle of a text stream, I

simply appropriated one, equated it to CLCTLC (CLear ConTroL C), and stuck it into the text stream. After adding the appropriate code to the interpreter, I reduced the above monstrosity to:

|      | ;text                           |  |  |
|------|---------------------------------|--|--|
| ASC  | "The last text in the first     |  |  |
|      | block.''                        |  |  |
| BYTE | CLCTLC ;clear output            |  |  |
|      | suppression                     |  |  |
| ASC  | "First text in the next block." |  |  |
|      | ;more text                      |  |  |

This was the start of something big (or, rather, something small!). There were several other flags whose entire manipulation could be compressed in the same way. Eventually, I added a lot more to the routine. I added escape codes that would switch to a different interpreter altogether. I added a set of conditional test codes that allowed me to output one of two strings depending on the state of various flags. I even added a code that allowed me to call any machine-language subroutine anywhere and then return to interpreted execution upon encountering the RTS from the called routine (an interpreted JSR instruction). This one was particularly useful because it allowed me to perform special-purpose routines without the code overhead of leaving the text output interpreter.

I never ran into any difficulties with this heavily interpreted approach, and I was able to reduce the code overhead vastly for "stupid little stuff" that I had to do repeatedly. If your application is time critical, you might not want to use a mini-interpreter. But because code size was far more important to me than the time required to execute the instructions, this approach was perfect for my on-line system, which you can dial up today at (408) 338-9511.

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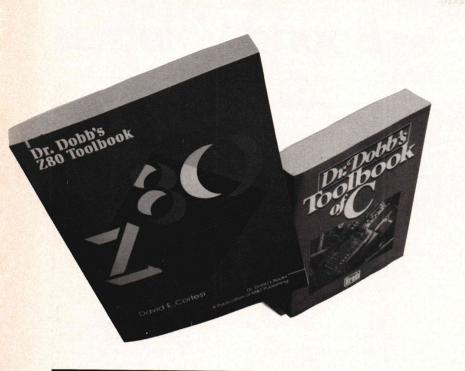
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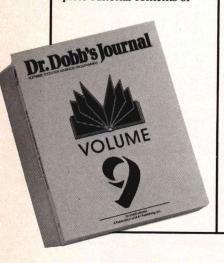
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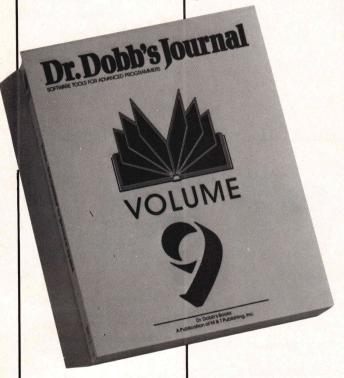
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The working notes of a technological revolution. Programmers from Defense laboratory systems analysts to kitchen-table entrepreneurs worked for the intrinsic rewards to put development software on the brand-new invention, the microcomputer. Before there was an Apple, Dr. Dobb's Journal of Tiny Basic Calisthenics and Orthodontia (subtitle: Running Light without Overbyte) was founded to put a programming language on the machines, and became both chronicler and instrument of the revolution. In this first-year volume: Tiny Basic, the first word on CP/M, notes on building an IMSAI, floating-point and timer routines.

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The roots of Silicon Valley growth. In 1978 Steve Wozniak and other programmers were publishing in Dr. Dobb's Journal code that would help them grow multimillion-dollar computer companies. The proposed S-100 bus standard was hashed out in Dr. Dobb's pages. Dr. Dobb's contributors began to speak more in terms of technique than of specific implementations as the industry began to diversify. Languages covered in depth included SAM76, Pilot, Pascal, and Lisp.

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The preeminence of CP/M and the rise of C. More than any other magazine. Dr. Dobb's Journal was responsible for the spread of CP/M and C on microcomputers. Both of those movements began in 1980. Dr. Dobb's all-CP/M issue, including Gary Kildall's history of CP/M, sold out within weeks of publication. This was the year of Ron Cain's original Small C compiler, of a CP/M-oriented C interpreter, CP/M-to-UCSD Pascal file conversion techniques, and of a greater concern in Dr. Dobb's with software portability.

#### Bound Volume 6: 1981

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The first of Forth, 1981 saw Dr. Dobb's first all-Forth issue (now sold out), along with an emphasis on CP/M. C. telecommunications, and new languages. David Cortesi began "Dr. Dobb's Clinic." one of the magazine's most popular features. Highlights included information on PCNET, the Conference Tree, the Electronic Phone Book, Tiny Basic for the 6809, writing your own compiler, and a systems programming language.

#### Bound Volume 7: 1982

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Legitimacy, By 1982 IBM had become a player in the personal computer game and was changing the rules. New microprocessors arrived. the first designed specifically to serve as personal computer CPUs. In Dr. Dobb's Journal Dave Cortesi published the first serious comparison of MS DOS and CP/M-86. Dr. Dobb's started two new columns: the CP/M Exchange, as a rearguard

maneuver to ensure that good tools for CP/M programmers would continue to be developed and circulated, and the 16-Bit Software Toolbox to investigate the 8088/86 and other new microprocessors. We published code for the 68000 and Z8000 processors, and looked ahead, in a provocative essay, to fifth-generation computers.

#### Bound Volume 8: 1983

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Power tools, Personal computers were proving themselves to be true professional software development tools by 1983, the year in which Jim Hendrix completed his "canonical" version of Small C in Dr. Dobb's Journal. Dr. Dobb's published more 68000 and 8088 code, and as the memory limitations relaxed, the magazine's commitment to tight code let it shoehorn impossibly large systems into memory. Small C was just one of the major software products

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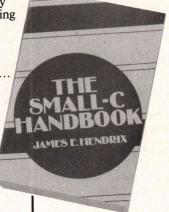
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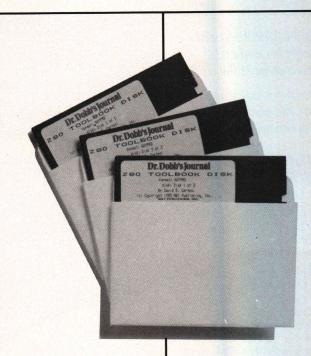
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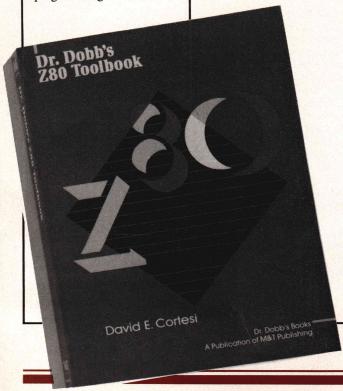
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#### **Poor Person Software**

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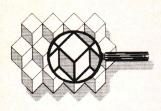
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#### OF INTEREST



The theme of this month's column is user-interface design.

The Research Group has announced SayWhat?!, a productivity tool designed to shorten the time required for screen design and at the same time increase the impact of screen displays for dBASE II and III, BASIC, and Turbo Pascal programs. It is an unprotected menuless system that allows users to create and edit displays on the screen without writing any programming commands or modules. The program requires an IBM PC/XT/AT or compatible with a minimum of 128K (384K required for dBASE III), DOS 2.0 or later, one disk drive, and a monochrome or color monitor. It retails for \$39.95.

Wendin is offering three new products: Operating System Toolbox, PCVMS, and PCUnix. Operating System Toolbox allows users to modify and tailor operating system software. Full source code is available. All enhanced system services, paged memory management, concurrent input/ output, and a multitasking scheduler can be used to construct powerful personal operating systems for the IBM PC/XT/AT. The price is \$99. PCVMS is an operating system that provides multiple processes, networking software, and a command set, plus a set of VAX-like system services. The price with source code included is \$49. PCUnix features utilities such as at, grep, mail, nice, and who. The price is \$49.

#### For C

Gimpel Software has announced Amiga-Lint, a diagnostic facility for the C programming language that runs on the Commodore Amiga. Amiga-Lint analyzes C programs and reports on bugs, glitches, and inconsistencies. Among the errors reported on by Amiga-Lint are type inconsistencies across modules, parameter-argument mismatches, library usage irregularities, uninitialized variables, value-return inconsistencies, variables declared but not used, suspicious use of operators, and unreachable code. Amiga-Lint runs under Amiga's CL1 interface and is available for \$98.

Retrieval Technology Corp. (RTC) has available the All-Hands-on C Video Workshop, a six-module, five-hour workshop designed to teach the full features of C.

Desktop A.I. has released a translator that allows users to move dBASE programs into C. The dBx Translator system includes a language translator for processing dBASE source code and a run-time library toolbox to replace the dBASE screen handler. The system is designed to work with any C database manager. In addition, applications can be moved to machines on which dBASE is not available, such as the AT&T 3B2 under Unix, Altos under Xenix, and Macintosh or Amiga systems. The package price ranges from \$350 to \$1,000, depending on configuration.

The C-Board is a stand-

alone C language development system from HiTech Equipment that can be used on a single STD buscompatible board. The C-Board requires a 5V 0.5A power source or unregulated 7-9V DC using an optional on-card regulator. The product features a CPU with parallel and serial I/ O. timer/counters with PWN output, EPROMs and EEPROMs, a threaded interpreter, and interactive development. The OEM version of the card without memory devices or manuals costs \$199. Volume discounts are available.

A PC- and VAX-hosted C cross-compiler supporting Intel's 8-bit MCS-51 microcontroller family is available from Archimedes Software. The C-based software development kit implements the proposed ANSI standard for C compilers and also comes with an assembler. The software is available for IBM PC/XT/AT or compatible systems equipped with at least 512K RAM and using MS DOS 2.0 or later. Initially, the software is also available for Digital Equipment's VAX/Unix minicomputer. The PC-based version is \$851; the VAX/Unix version is \$3,500. VAX/VMS and MicroVAX versions will also be available.

Alcyon has expanded its optimizing C compiler line to include cross-development versions for the IBM PC/XT/AT. The C68 compiler, priced at \$795, produces optimized code for the M68000/010. The C68/020, priced at \$995, produces optimized code for the M68020/68881. Minimum requirements are an IBM PC/XT/AT, 5-megabyte hard disk, 512K, and PC DOS/MS DOS 3.0 or later. In addition

to the IBM PC, Alcyon's C compilers can be hosted on systems with Motorola VersaDOS, DEC VAX/VMX, and DEC VAX/Unix.

The C Trainer Interpreter from Catalytix provides users with an interactive interpreter for the full C language. The interpreter enables users to run C code without compiling it. Furthermore, the interpreter's design permits users to run program fragments without requiring that all functions and libraries be present at run time. The book The C Trainer, published by Prentice-Hall, accompanies the interpreter and combines a step-by-step tutorial with a separate reference section explaining many aspects of C. The tutorial's format is such that readers build upon existing programs that help them understand C in an interactive fashion. The C Trainer Interpreter runs on the IBM PC and compatibles, as well as the Macintosh. Versions are also available for Unix and for VAX/VMS computer systems.

CDEBUG (Version 2) from Complete Software is a portable Clanguage debugger that shows all C objects according to their name and type and lets users set unlimited break and trace points by using regular expressions. Requiring minimal overhead, the interactive program consists of a preprocessor to insert symbol tables into source code and a run-time library to interpret and integrate with a user environment. CDEBUG is available for MS DOS, Lattice, Computer Innovations, Wizard, VAX/ VMS, Unix, and Xenix operating systems on disk or tape media and will be ported. The new version is priced from \$350 for PCs and \$750 for the Unix porting service.

Fortrix-C from Rapitech Systems is designed to recognize and convert most FORTRAN VMS extensions and translate a typical 50,000-line program into C code on VMS. All comment lines remain in place so internal documentation is retained.

#### For the IBM PC

Midwest Micro-Tek has released Circuit Design Mate, a software product for the IBM PC and compatibles that includes schematic capture, automatic parts list generation, TTL component library and editor, and schematic printing on any Epson-compatible dotmatrix printer. The system requires an IBM PC/XT/AT or compatible with 256K, a  $640 \times 200$  IBM-compatible graphics card, two doublesided disk drives or one disk drive and hard disk. and PC DOS/MS DOS 2.0 or later. A single copy with TTL library is \$295.

Macmillan Software has unveiled a menu-driven software package for PCs. Called Asystant Ready-to-Run Scientific Software, the package is a high-level programming language with acquisition, analysis, and graphics capabilities. Asystant runs on IBM PCs and compatibles, including the Hewlett-Packard Vectra, and uses the 8087 coprocessor. A second version of the product, called Asystant +, adds data acquisition and includes built-in interactive data manipulation, analysis, and high-resolution color graphics. Asystant is priced at \$495, and Asystant + costs \$895.

Dasoft Design Systems' PC2 features an auto-router, expandable symbol library, enhanced footprint

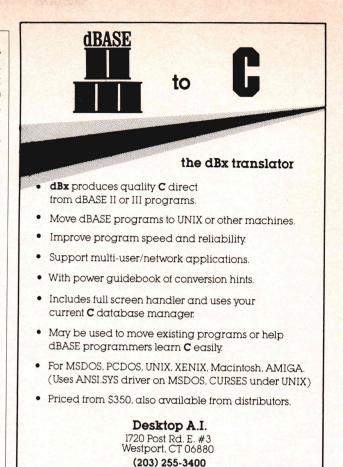
editor with six pad shapes and user-definable pad layouts, and a component "data book" library of 600 commonly used parts. The PC2 can be used on the IBM XT/AT and compatibles with 512K, a monochrome graphics card, hard-disk storage, and a mouse. The software also runs on the AT&T 6300 and the NEC 9801. It drives most plotters including those from Hewlett-Packard, Houston Instruments. Western Graphtek, Ioline, and compatibles. The software is available for \$3,495.

The PC-NTDS Adapter Card, a full 32-bit parallel NTDS (MIL-STD 1397) interface board, is available from Sabtech Industries The adapter installed in an IBM PC/AT utilizes the full 16-bit data path of the AT and can output data at speeds of up to one 32-bit word every 1.2 microseconds. This represents a transfer rate of up to 834K 32-bit words per second. Software included with the NTDS Adapter Card has its own interface control language, including highlevel commands such as loop, repeat, and compare.

#### Utilities

Sophco has released Sybil. a collection of utilities that can unerase files, edit sectors, modify file and directory attributes, and find files. Sybil comes with a print spooler, a RAMdisk, a general-regulation expression parser, and a graphics editor called ASCIIGEN (for RGB and IBM monochrome). It runs on the IBM PC/XT/AT and compatibles and on both 8088 and 80286 computers. Sybil is priced at \$49.95.

Avocet Systems has released AVSIM09, a software simulator/debugger for the 6809 microprocessor. Running on any IBM PC



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(continued from page 123)

look-alike, AVSIM09 interpretively executes 6809 object code under control of a full-screen symbolic debugger. Devices supported include the 6821 PIA (Parallel Interface Adaptor), 6840 PTM (Programmable Timer Module), and 6850 ACIA (Asynchronous Communications Interface Adapter). AVSIM09 is priced at \$299.

Modula-2 has been added to the list of languages recognized by Source Print, Aldebaran Laboratories' multifunction, source-code formatting utility. For Modula-2, Source Print can draw lines to indicate module and procedure nestings as well as nestings of if, while, for, case, loop, and repeat structures. Automatic indentation can also be performed. Additional features include facilities for indexes, tables of contents, pagination, line numbering, keyword emphasis, extraction of routines, and extensive printer control. Source Print is for IBM PC/ XT/AT and compatibles. The source formatting utility with 88-page manual is \$97.

Written in RM COBOL, Myte Myke Software from M & D Systems supports both single-user and multiuser microcomputers as well as the more advanced local-area networks including Novell and is designed to take advantage of the expanding computing power of various microcomputing systems. The software can be used with Unix Version V on Sperry 5000, AT&T 3B Series, and NCR Tower Installations.

ZLKO from Elliam Associates is used to link relocatable object files created by ZMAC or other assemblers that use the Microsoft REL format. ZLKO can be

used with compilers for FORTRAN, BASIC, COBOL, or C. ZLKO links the program on disk rather than in memory and thus links a program that will fill the entire available memory space. It produces a symbol table for debugging and can be used to segment a program that will not fit into memory into a tree structure of overlays. The price for the disk and instruction manual is \$49.95.

CompuMagic has released a package of 20 superutility programs for anyone using CP/M 2.2. There are three sets of programs. The File Management programs CMCopy, Erase, Rename, Compare, Sort, DoubleSpace, and WordCount allow wildcards, multiple commands on a line, and ask-me and test options, in addition to user-area switching. The Director programs MDIR and MDIRS take multiple file specifications. DIRBAK provides a list of all backup files, and DIRSPACE reveals how many directory entries are left. UDIR lists all the files in user areas, and DiskDIF tells what files are on one disk but not another.

In the Special Utilites programs, CMAuto allows the creation of programs to run other programs; TYPIT turns a computer into an electronic typewriter; and A.COM corrects the common A;program typo and turns it into A:program. Screen puts everything on the screen into a file, and R/O and R/W are replacements for STAT's command to convert files to read/ only or read/write. Miniera is a 1K program that allows erasing. The complete package is \$45.

**Computer-Guru** has introduced Salt & Pepper, a software program that contains 29 subroutine mod-

ules in MS DOS-compatible BASIC. The modules are saved in ASCII format and can be lifted from disk and merged into a user's program. The programmer can then use single-line commands to accomplish tasks such as creating professional menus and input screens, processing dates, changing strings to uppercase or lowercase, creating "walking" strings, trapping errors, and issuing Caps-Lock on/off. The package is available for \$59.95.

UX Software has announced the UX-BASIC Native Code Compiler to complement the UX-BASIC Interpreter (Version 2.1). UX-BASIC features structured code; modular programming; sequential, direct, and ISAM files; and editing and debugging tools. It is functionally compatible with IBM's IX BASIC. Prices vary according to the class of target computer.

**Software Products &** Services (SPS) has expanded its EPOS engineering and software development environment to include tools for the automatic generation of Pascal code. The EPOS software system supports project design and development from the formulation of requirements to a complete design and system maintenance throughout the entire life cycle of a project. It also contains integrated management tools for project control. The system is language-independent and supports seven design methodologies.

#### For Apple

SuperMac Technology has introduced three Macintosh add-on boards. Enhancements include Meg, a 1-megabyte memory expansion board designed to coexist with internal hard disks; SuperDrive 20, a high-performance, 20-megabyte, 3½-inch internal hard disk designed to improve the Macintosh's file access speed up to ten times; and Enhance, a clipon board that gives the original Macintosh 2 megabytes of contiguous RAM and a Macintosh Plus-compatible Small Computer System Interface (SCSI) port. Meg is available for \$849 for upgrading from 128K and for \$699 for upgrading from a 512K Macintosh. SuperDrive costs \$1,299. Enhance can be expanded to 4 megabytes or more; its price has not yet been announced.

ProFiler 2.1, a data manager/report generator for Apple II series computers, now has its utility program integrated into the overall program. The utility feature allows transfer of data between ProFiler and AppleWorks. ProFiler 2.1 can design, organize, file, search, sort, merge, calculate, and print reports and run on either floppy or hard disks. The menu-driven program can store up to 1,500 records on a floppy disk or up to 65,000 records on a hard disk. No additional data entry is required to transfer data from one medium to another. The entire program, including the utility program, sells for \$99.95 and is available from PM Software.

Transwarp, an accelerator card that speeds up both the main and auxiliary memory of an Apple IIe computer, is available from Applied Engineering. The accelerator works with all Apple II+ and IIe software, including AppleWorks, SuperCalc 3a, and VisiCalc, and is compatible with all standard peripheral cards. The \$279 board plugs into any available slot in Apple II, II+, and IIe computers.

Odesta has unveiled

four Helix products for the Macintosh Plus. Helix is a database informationmanagement and decisionsupport system that allows individuals to build applications tailored to their specific needs. Double Helix allows users to create custom menus and install security to protect the structure of their applications. Value-added resellers and application publishers can build stand-alone vertical packages with Run-Time Helix. MultiUser Helix allows networked users to work simultaneously with a customized Helix application. Helix and Double Helix for the Macintosh Plus and 512K Macintosh are available for \$395 and \$495, respectively. Run-Time Helix for both Macintosh prod-

ucts can be licensed for a fee of \$500 for ten applications. The price has not yet been determined for MultiUser Helix.

#### Communications

Practical Peripherals' Modem 1200 is Hayes-compatible and supports pulse or touch-tone dialing in full- or half-duplex operation. It self-adjusts to varying transmission speeds from 300 to 1,200 bits per second. The product conforms to all Bell 212A and 103 standards and complies with the requirements of FCC Part 68 for direct connection to public phone lines. The  $4 \times 5$ inch card is installed in either a short or long slot within IBM PC/XT/AT or compatible computers.

The Dual Serial Port

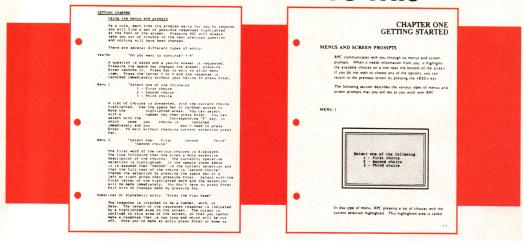
Manager (DSPM) is a hardware/software interface program. Available from Akron Software, DSPM has a full-interrupt drive, automatically buffers all received and transmitted data, and allows users to specify the size of each buffer independently. It also allows an application program to use both COM1 and COM2 simultaneously and supports three datatransfer protocols. The DSPM package provides interfaces to programs written in Pascal, C, compiled or interpreted BASIC, FOR-TRAN, and assembly language. It costs \$99.

**Quasitronics** has announced the Pipe Six, an intelligent data switch that has six RS-232 I/O ports that provide communications between dissimilar

systems and/or peripherals operating with different baud rates, word structures, and flow control techniques. The system features 54K of allocated memory for speed conversion, printer buffering, message storage, and private mail. It can handle concurrent communciations between all of its fully interactive ports.

Unlimited Processing has announced Team-Up, a Total Environment for Application Management. Team-Up adds application management to data management functions by managing up to 32,000 applications containing up to 700,000 files. It tracks file existence, file names, server/directory file locations, and user-access authorizations. Prices range from

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OF INTEREST

(continued from page 125)

\$795 to \$4,495, depending on configuration.

#### Miscellaneous

USecure, a system security and administration product for Unix-based computers, is available from Unitech Software. USecure is menu-driven and provides automated system access control and audit trails of system changes, file modifications, access permissions, deleted files, and start-up and shutdown activity. Pricing varies from \$300 on a PC to \$2,500 on a mainframe.

Logicraft's GraVAX brings high-scale resolution graphics and PC compatibility to the VAX environment while maintaining the VT-100 DEC terminal capabilities. GrafVAX is a bus extension of the company's Cardware product line and consists of two components. The Q-bus version, which plugs directly in the DEC Q-bus, is priced at \$2,990 per user, and the Unibus version, which can be located up to 4,000 feet from the CPU, is priced at \$5,980 per unit.

The MII-1 Bubbl-Board, a bubble-memory system from Bubbl-tec allows Multibus II machines to make use of solid-state mass storage in applications for which electromechanical media such as disk and tape are unsuitable. The MII-1 system provides 512K of nonvolatile mass storage on singlewide Multibus II module and incorporates an intelligent controller that handles device formatting and control, interfaces the bubble-memory system to the Multibus II bus structure, and provides for both soft- and hard-error detection and correction. The system is also expandable to 32 megabytes. The 512K version is priced at \$2,899 in quantities of ten. Versions with smaller amounts of onboard storage capacity are also available.

#### Reference Map

Akron Software, 53 Hillside Ave., Toronto, Ont., Canada M8V 187; (416) 251-1866. Reader Service Number 16.

Alcyon Corp., 5010 Shoreham Pl., San Diego, CA 92122; (619) 587-1155. Reader Service Number 17.

Aldebaran Laboratories Inc., 3738 Mt. Diablo Blvd., #312, Lafayette, CA 94549; (415) 283-7084. Reader Service Number 18.

Applied Engineering, P.O. Box 798, Carrollton, TX 75006; (214) 241-6060. Reader Service Number 19.

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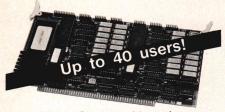
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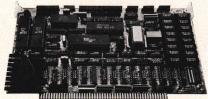


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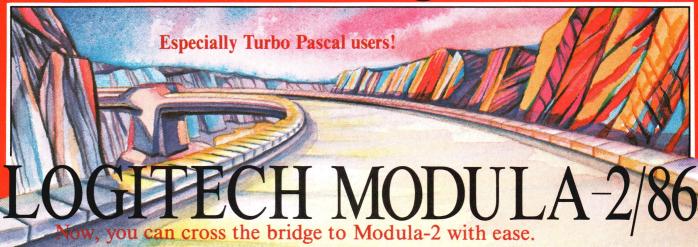
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